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The Field for Weldings

After a period of exaggerated claims and extravagant applications, the true sphere of weldings in the engineering industries has been well stated by Dr. S. F. Dorey in a Paper he presented to the Institution of Engineers and Shipbuilders in Scotland, and an extract of which appears elsewhere in this issue. Weldings should be used in the following circumstances: "(1) When it is important to restrict weight to a minimum, and (2) when it is considered that a better or more suitable article can be made by the use of welding." With such views no one can quarrel, especially when, during the elaboration of these views, Dr. Dorey points out that "Rigidity is an inherent quality of cast iron and in this respect is superior to mild steel." Despite this, it is maintained that a weight saving of 20 to 40 per cent. is rendered possible by the substitution of welding for iron castings. The author cites as an example the case of a 750-ton keel bending press, which had its baseplate made as a welding for replacing a broken casting. The former weighed 39 tons as against 48 tons for the casting, yielding a saving in weight of the order of 20 per cent.

Almost synchronously with this experience, there appeared an article in the technical Press by Mr. E. V. Crane, research engineer to the E. W. Bliss Company, the well-known press constructors, which outlined a comparison of the economics and performance of two identical presses built for the same performance, the one a welded construction and the other an assembly of castings. "Both presses were used in the same plant at the same time. On the basis of this and other experiments with machines of this type, the Bliss Company has come to the conclusion that, in the fabrication of heavy presses, the successful and enduring operation of which is dependent upon rigidity of construction, iron castings possessing the necessary engineering properties will meet the requirements better than any other commercial material." So far as cost is concerned, the experience of the Bliss concern was that the cast-iron assembly was £160 less than that of the welded structure. It should be pointed out that full advantage is now being taken of high-duty cast iron and the better performance of the press made from castings was due to vibration damping or shock-absorbing properties of good cast iron. This factor should be sufficient to warrant the use of iron castings by the machine-tool builders for a long time to come.

Another point made by Dr. Dorey was that where a series of similar components was called for, costs were loaded in favour of the foundry, but the reverse applied in the case of a one-off job involving much patternmaking. A factor which has not been dealt with by authors of articles on weldings is the waste which must be involved through cutting out shapes from standard sizes of steel plates. The long-established art of cutting suits from a length of cloth involves a minimum of waste, but for diverse engineering jobs the scrap must be serious. To hoard odd bits and pieces on the chance that they might "come in" for another job must operate against orderly working and a tidy shop.

The rules laid down for the design of weldings should serve to emphasise that each process deserves and demands similar treatment, and too much stress cannot be placed on the need for the fullest co-operation between the drawing office and the foundry department. The help given to the welding industry by the designer is indeed praiseworthy and its results have been far-reaching. Efforts are required by the foundry industry to rationalise the established notion that any shape, no matter how complex, can be made as a casting. The truth is that whilst any shape can be reproduced, it needs full co-operation of all concerned to effect the maximum economy and to yield a job having high and uniform mechanical properties.

Whilst Dr. Dorey cited several examples of composite structures, that is, assemblies of castings and weldings, we are not satisfied that this development is making the progress which, superficially at least, its potentialities indicate. Moreover, American literature does not disclose outstanding progress in that country. We attribute this to the lack of balance in the training of the average designer.

From an impartial study of Dr. Dorey's Paper, it is evident that a certain amount of work will be lost to the welder, but if the final result is a cheaper and more economical production, then, as it will react upon trade in general, other sections of the foundry industry will thereby benefit.

D

Metal Exchange Methods

BY "ONLOOKER."

To many people it must seem strange that London should normally be the centre of the world's trading in non-ferrous metals, for our domestic production of these essential commodities from native ores has never been large, although we do to-day possess up-to-date and highly efficient plant for producing tin and zinc. There is also a modest output of pig lead which is accounted of excellent quality, but the copper smelting industry which during the last century flourished in South Wales is a thing of the past. We have, of course, copper refineries of the latest type and proved excellence, but these are treating blister and scrap almost entirely, the former being imported from abroad.

All this shows that while there is an important industry in this country engaged in producing base metals, much of the raw material in the shape of concentrates and waste comes from abroad. Nevertheless it is claimed that, apart from those periods when for one reason or another trading on the London Metal Exchange is under a cloud, the centre and focus of business in non-ferrous metals is situated in Whittington Avenue. The reason is not far to seek, for London constitutes a free market which is able and willing to deal with all the business that comes to it, even though it is crowded into one session. Moreover, up to a few years ago, import duties on metals were unknown in this country, and even now with lead and spelter subject to a tariff this difficulty is surmounted by means of permitted premiums on Empire metal and a system of bonded warehouses. It therefore follows that sales made on the London Metal Exchange may be implemented by deliveries into official warehouses in this country.

American Rivalry

The only really serious rival to the London Metal Exchange is the National Commodity Exchange in New York, and activity there has undoubtedly increased as a result of the shutting down in Whittington Avenue. This applies particularly to copper, in connection with which it is interesting to note that according to the Commodity Exchange's Report for 1939 the number of contracts (25 tons) recorded was 19,810, compared with 15,889 in the preceding year and 14,983 in 1937. In the year before the number was under 5,000, but both in London and New York 1936 was rather an off-period for dealing in futures. To show the progress made by New York in the post-war years it may be noted that whereas in 1935 and 1936 the turnover in copper warrants on the Commodity Exchange was about one third of London, 1937 showed a comparison of rather more than one half, the actual figures being 369,375 tons against 711,375 tons.

In the other metals last year's Commodity Exchange report shows the comparative figures of warrants traded during 1938 and 1939 as 440 and 824 in tin (nearly 100 per cent. up), 877 and 804 in lead and 190 and 425 in zinc. It will be noticed that although copper puts up a good showing the figures for the other three metals are a long way behind an average year in London.

Perhaps what has helped the London market more than anything has been a well-merited reputation for the ability to give operators a square deal. In other words, a heavy bout of selling has not brought too serious a break in values and when big buying orders came on to the market, would-be purchasers have not been mulcted. In fact, the London market is established on a broad basis and does not normally suffer from the complaint sometimes voiced by operators in futures that operators are "making a price." In the difficult days which will follow the war the steadying influence of Whittington Avenue may be badly needed.

The Late Mr. W. H. Sherburn

We deeply regret to record the death of Mr. W. H. Sherburn, which took place on February 21 at his residence near Warrington.

Mr. Sherburn was born in Rotherham, Yorks, almost 87 years ago and served an apprenticeship to patternmaking in that then centre of the stove-grate industry. He studied art alongside his practical work, and earning several national awards, became a teacher at the Rotherham School of Art. During that period he designed and executed cast-iron work for W. & A. C. Russell & Company, of Manchester, and later took up an appointment with that firm. Through this association he became closely connected as a co-worker with Thomas Fletcher, of Warrington, and was thus identified when the amalgamation into Fletcher, Russell & Company, Limited, was completed. Ordered away from Manchester owing to failing health, he reluctantly severed his connection with the firm in 1896.

For a short time he was with R. & A. Main, Limited, during which period he entered the Falkirk Town Council and served on the Gas Committee of that town.

His business connection with Richmonds Gas Stove Company, Limited, began in 1901 and continued up to his retirement; he acted in a consulting capacity until his decease. A pioneer of interchangeability and simplicity in construction, his outstanding efforts were the "Bungalow" cookers and A.B.C. fires of that company. As a student of natural science he welcomed the aid of scientific knowledge to the solution of the problems of industry.

Oliver Stubbs Medallist

Intensely interested in education, Mr. Sherburn was a founder of the Institute of British Foundrymen, of which he became a life member, and the Oliver Stubbs Gold Medal was awarded to him in 1923 for outstanding work for that body. He took a profound interest in the Lancashire Branch and presided over its destinies in the critical period of 1906 to 1908, that is just two years after the foundation of the Institute. Until quite recently, he was a regular participant in the annual conferences. For many years he was a Fellow of the Royal Society of Arts. As a craftsman and technician he gave much encouragement to working people to develop mental power, although his favourite quotation was "Kid gloves are perfect insulators against knowledge."

Notwithstanding his business activities he was a lover of learning and biography, sociology, political economy and writings upon religious subjects exercised his active mind, whilst he was a clear and convincing speaker. His admiration for Joseph Priestley impelled him to design and execute a tablet in bronze which now marks the Warrington residence of this famous scientist.

The recent loss of his wife after 63 years of devoted companionship inflicted a severe strain upon his failing strength. His personal charm, dignity, and his broad outlook won fast friends in many walks of life, and his philosophic calm and understanding mind will long remain a delightful memory to all those who knew him.

Book Review

Standard Screw Threads and Twist Drills. By George Gentry. Published by Percival Marshall & Company, Limited, 60, Kingsway, London, W.C.2. Price 1s. 6d.

This edition has been enlarged so that now the ranges of sizes under the Whitworth Standard have been carried from ½ in. to 1¼ in., a subject dealt with in the first chapter. The object of the book is to help mechanics to overcome difficulties arising through the constant recurrence of non-standardised threads in industrial apparatus, and this has been well achieved.

Random Shots

There is no doubt about it that small children these days hear and see a great deal more of the grown-up world than the children of the last generation were wont to do. Thus one small girl, the daughter of a foundryman, so accustomed is she to hearing "shop" at mealtimes, even calls her latest doll "Baby Bessemer."

* * *

The same little girl asked her august parent the other day if he would take her to a Socialist party as soon as the war is over! So Daddy had to explain the differences between political parties (including Socialism) on the one hand and socials and . . . . well, just parties on the other hand. To do this he quoted a cute observation recently made by an American contemporary on the present political "set up." This is how it went.

(*a*) *Socialism.*—You have two cows. You give one to your neighbour.

(*b*) *Communism.*—You have two cows. You give both to the Government. The Government gives you the milk.

(*c*) *Fascism.* You have two cows. You keep the cows and give the milk to the Government. The Government sells part of it back to you.

(*d*) *Nazism.*—You have two cows. The Government shoots you and takes both cows.

(*e*) *New Dealism.*—You have two cows. The Government shoots one, milks the other and pours the milk down the drain.

(*f*) *Capitalism.*—You have two cows. You sell one and buy a bull.

* * *

'Tis an ill wind that blows no one any good, the old saying goes, and, considering this winter's weather, many will have been thanking Hitler that they have not had to freeze at Castle Bromwich, as is their wont in February.

* * *

Scrap metal is being collected in Nice at the rate of two tons an hour by soldiers with lorries, reads a report from France. Poor old Nice! To think that before the war it was gold and not old iron which one could scoop up in the casinos!

* * *

"It's grand in the country," writes a young evacuee to his mother. "Even cabbages grow wild in the fields."

"MARKSMAN."

Heat-Treated Cast-Iron Pistons

According to O. GLASER, writing in "Die Giesserei," pistons for small rotary pumps can advantageously be made of cast iron provided the composition is suitable and appropriate heat treatment is given. In his experiments he used electrically-melted cast iron containing C 3.1 to 3.3; Si 1.8 to 2.4; Mn 0.6 to 0.8; and S and P 1.0 per cent., which was cast into chills and annealed at 850 deg. C., after which it was quenched in oil and tempered for several hours in oil. The pistons exhibited the following characteristics:—

Cast no.	T.C.	Graphite.		Si.	Brinell no.	
		Annealed.	Hardened.		Annealed.	Hardened.
1 ..	3.23	3.10	2.49	2.12	174	461
2 ..	3.21	3.11	2.51	2.17	182	421
3 ..	3.31	3.18	2.75	2.37	192	388

Where case-hardened steel had previously shown growth, the heat-treated cast-iron components were very wear resistant, and maintained both dimensional accuracy and hardness.

A Modern Foundry in Palestine

By ALEXANDER KREMENER*

The writer arrived in Palestine in April, 1934, chose a plot of land in the desert near Haifa, and commenced the removal of some 12,000 cubic yards of sand in order to prepare a level site for the erection of foundry buildings. By November of that year, that is barely eight months after the choice of the site, the first metal was cast into moulds.

The foundry is housed in a shop 180 ft. long, consisting of a main bay and two side bays 90 ft. wide. The shops are serviced by four overhead travelling cranes, two of 7½ tons and two of 3 tons lifting capacity. The crane track of the fettling shop is continued across the yard, to handle the heavy castings directly to the despatch department, and also to transport fettled bath-tub castings directly into the enamelling shop.

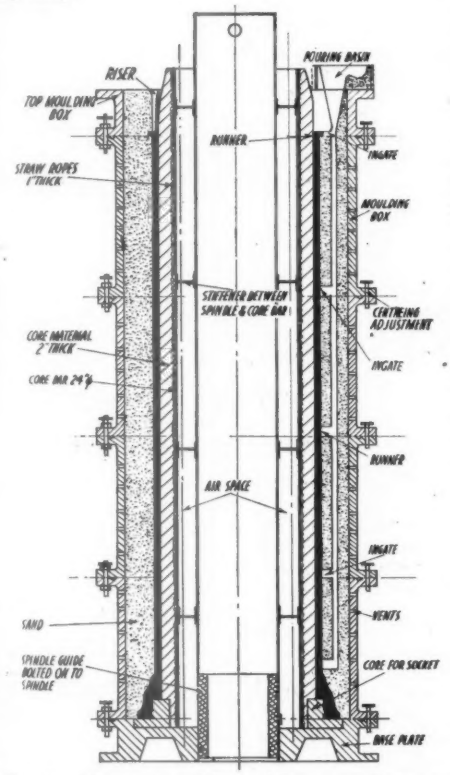


FIG. 1.—METHOD OF MAKING PRESSURE-RESISTING PIPES, 30-IN. DIA., IN 9-FT. LENGTHS.

Melting is effected by two 4-ton per hour cupolas erected in the side bay. The raw materials are transported from the storage bins in wheeled bogies running on a light-gauge rail track, and in doing so pass over an automatic weighing machine. On arrival at the cupola the contents are handled by an automatic charging machine. For a daily output of 10 tons, this lay-out demands the services of one cupola tenter, who is also responsible for the patching, and two labourers. The latter attend to the breaking up of pig-iron and scrap, the preparation of the charges and general maintenance.

The melting capacity is supplemented by a 6-ton electric furnace, as the intention is to make steel castings in the future. It is not yet, however, in production.

Sand is prepared in a fully automatic sand conditioning plant, well capable of handling 15 tons per hour. It furnishes material for all sections of the plant.

Moulding Plant

A wide range of various types of jarring machines has been installed to enable the management economically to undertake the diverse needs of the local market. The largest machine has a table 13 ft. 4 in. by 4 ft., and is capable of lifting over 4 tons. The smallest is 14 in. by 12 in., and all are hydraulically lifted and turned over. A large Herman machine is used for the moulding of bath tubs, and with it five semi-skilled men are turning out five complete moulds for a standard bath per hour. This figure includes closing up ready for pouring. A piece-work rate of 2s. per bath is accorded and rejections are negligible.

It is thought that the installation of a second jar rollover machine for the making of top parts only would double the hourly production whilst not otherwise extending the existing plant.

Fettling

The fettling shop is equipped with all the necessary plant such as a shot-blast chamber, used mainly for cleaning baths; a rotary table for smaller items; tumbling barrels for pipes, etc.; swing grinders, pneumatic hand grinders, and a battery of grinding machines, all independently driven, a system used throughout the entire plant. A powerful dust-extraction plant ensures healthy conditions throughout the fettling shop. A fully-equipped patternshop is well capable of supplying the foundry with the most intricate patterns of a serviceable character.

A machine shop is attached to the foundry and in it are installed a number of heavy general-purpose machine tools, the latest precision machines such as gear cutters and the like. The works is thus well placed for undertaking all normal repair and maintenance duties. It is the practice to plane and drill all box parts, under the supervision of the foundry foreman, so that he can assume full responsibility for their accuracy.

Some Typical Jobs

Below is given a description of two jobs exhibiting features of interest to the practical foundryman. The first relates to an urgent order received for some 9 ft. long, 30 in. diameter pressure-resisting pipes. There being no suitable moulding machine available, the problem of creating a special moulding plant arose, it being understood that the foundry was primarily designed for the production of bath tubs. Fig. 1 shows the design evolved by the author and successfully utilised by the local labour.

The method employed is almost self explanatory. The necessary boxes were made as an assembly of four circular parts 28 ins. in diameter. Each part-mould was rammed up on a jar-ramming machine using an iron pattern, assembly being effected by means of a guide over key way and spring. This gave a casting of even wall section free from any excessive joint markings. The core was made on a barrel mounted on a lathe running at 30 r.p.m. The core was released as soon as possible after the job was cast up in order to avoid any internal stress and to ensure proper shrinkage. The assembly of the box parts is both simple and rapid, and the core is well centred on the bottom plate by means of a tapered centre head and is kept strictly concentric.

A somewhat similar scheme, using the same boxes, was employed for making some 10-in. dia. pressure pipes. They were moulded four in a box, as is shown in Fig. 2. It was only necessary in this case to guide the cores in the top box. A special top box was made to carry the pouring basins and risers and (what is more important) to centre the four cores with due regard to accuracy. It is thought that this method is quite novel to foundry literature.

Enamelling Plant

As the plant makes bath tubs, a separate shop was built to house the enamelling department. It measures 90 ft. by 60 ft. and is particularly well lit and ventilated. Fusing is carried out in a solid-fuel-fired muffle furnace, the front of which is in alignment with the shop wall, that is, the actual furnace is built outside the shop. The door is of the sliding type. Pneumatic sieves are used for powdering the enamel over the bath, which is mounted on a universal turntable and transferred to the muffle by a balanced fork-like charging machine. The quality of the baths is such that they command a ready market in competition with the best European makes.

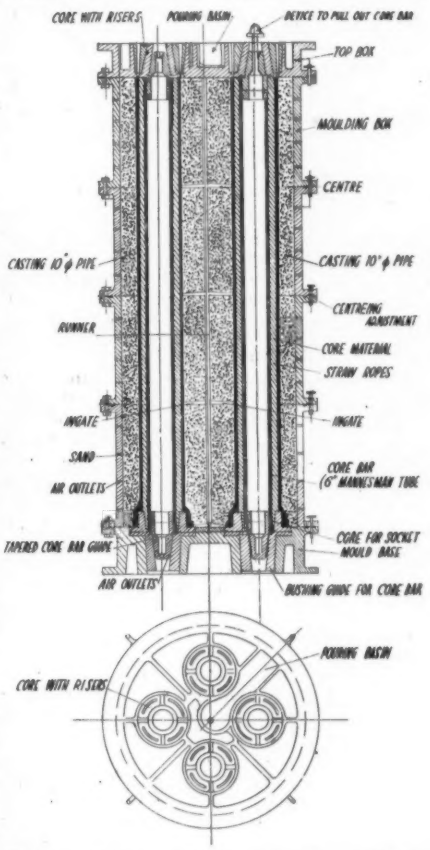


FIG. 2.—METHOD ADOPTED FOR MAKING 10-IN. DIA. PRESSURE PIPES.

Conclusion

It is interesting to point out that there were neither experts nor skilled men available in Palestine when the works was established, and the painful business of training the staff was beset with difficulties, especially since most of the employees were emigrants from Germany and included doctors, lawyers, business men—in fact, all types except foundrymen. The author had the assistance of his son, Heinz, and a well-known enameller, Mr. Lacy Kövarz. To-day, the foundry has a staff of highly-skilled men, who have applied themselves to their new duties with both skill and pride and who are now capable of giving a high rate of output.

Moulding and Casting Magnesium Alloys

The methods employed for moulding and casting magnesium alloys at an American plant producing 1,500 lbs. per day are discussed by A. H. Allen in a recent issue of "Steel."

* General Manager, Vulcan Foundries Limited, Haifa, Palestine; formerly general manager, Hartung A.-G., Lichtenberg, Berlin; Jacobmann A.-G., Borsegwalde, Berlin, and Landmashinenfabrik, Havel, Brandenburg.

Decorative Finishing of Aluminium-Alloy Castings

In addition to the ordinary fettling process, certain classes of aluminium-alloy castings may require additional finishing to enhance their appearance. Castings for ornamental and architectural applications, for which aluminium is ideally suited, can be supplied with a number of attractive finishes, applied either by mechanical, chemical or electro-chemical means. Their successful application depends to some extent on the shape and alloy of the object to be finished, as well as the skill of the operator, making it necessary to work out the most efficient system for each individual part. Only a few of the general practices, therefore, can be given.

Sand-blasting is a common means of applying a pleasing matte finish to aluminium castings. In using this practice for the finishing of large flat castings, and particularly castings which are later given a chemical or electro-chemical treatment, somewhat more care must be exercised in blasting than would be required for cleaning alone. Distance from nozzle to work, nozzle angle and size must be kept constant. Motion of the nozzle in blasting should be in parallel lines extending the full length of the work. Uniformity of the surface after blasting may not reflect the necessity for this control, but is reflected by many of the subsequent finishes that may be applied.

Polishing Procedure

Polished finishes are likewise among the mechanical finishes used for ornamental applications both as polished or as a base for subsequent chemical or electro-chemical finishes. Normally these are applied by using graded abrasives set up on wheels or belts, starting with coarser abrasives first and working down to the fineness desired. The number of steps required will depend on the type of casting and the equipment, and should be worked out for each job. For the rougher work, muslin or canvas wheel sections, glued together to provide a wheel of the desired thickness and set up with emery or fused aluminium oxide abrasives of the proper size, are quite suitable. Similar wheels, or shaped wheels of felt of the required degree of hardness, set up with emery, are used for the finer finishing.

Buffed and satin finishes also are applied readily with suitable wheels after the preliminary polishing. Sewn muslin wheels are suitable for buffing, using abrasive applied to the wheel face in a grease binder. Tripoli grease cake forms a good material for that purpose. Colouring following buffing is done with unsewn muslin or flannel wheels using lime or soft silica, mixed with a grease base. For satin finishing, wire wheels composed of nickel, stainless steel or German-silver wires of such a size as to give the desired surface texture are sometimes used. Greaseless polishing compounds used with muslin or canvas wheels will also provide a pleasing satin finish. A finish closely approaching a true satin likewise can be obtained on flat surfaces with a belt sanding machine using a cloth belt set up with No. 240 emery.

Recommended Wheel Speeds

Wheels for mechanical finishes may vary from about 6 to 20 in. in dia. Wheel speeds should be such as to minimise heating as well as any tendency to tear the abrasive out of the glue. A peripheral speed of about 6,000 ft. per min. should be sufficient for the polishing operations. Stick grease or tallow may be used to reduce the danger of burning. For buffing and colouring, wheel speeds of 7,000 to 8,000 ft. per min. are preferred. Wire wheels should be run relatively slowly to avoid excessive tearing of the metal, a peripheral speed of 700 to 900 ft. per min. being sufficient. Belts for polishing work on aluminium-alloy castings should be operated at speeds of 2,400 to 3,000 ft. per min. with a suitable lubricant.

Chemical Finishes

Chemical finishes are used to render more attractive the appearance of aluminium castings, as well as to improve resistance to corrosion, and adherence of paint. A number of solutions may be used for that purpose, although the initial cost of materials, safeness in handling, and ease of control are factors which will generally establish the one most preferable for any particular use. The nature of certain of the chemicals used makes it also desirable to have such solutions prepared by, and used under the direction of, someone familiar with the characteristics of these materials.

Various chemical etches are often employed as a means of improving the surface appearance. A 5 per cent. sodium hydroxide solution frequently is employed for this purpose, as is a solution of 5 per cent. sodium hydroxide and 4 per cent. sodium fluoride, both being used at a temperature of 160 to 180 deg. F. Time of treatment in either solution will depend on both concentration and temperature, and must be determined for the finish required.

After etching, the castings should be washed thoroughly in clear water and then transferred to a bath of nitric acid to neutralise any sodium hydroxide left on the surface and remove the coloured film left from the etch. A satisfactory nitric acid solution is made up by mixing two parts of concentrated nitric acid with one part of water. For castings containing substantial amounts of silicon, the addition of 1 part of hydrofluoric acid to 8 parts of nitric acid promotes better removal of this film. A final rinse in clear water completes the etching procedure.

Several chemical treatments which provide a protective oxide coating also are available for use with aluminium castings. Such chemical treatments are suitable for many applications as the coatings formed provide improved resistance to corrosion, and make a good base for subsequent paint coatings. They are less expensive to apply than the electrolytic oxide coatings.

Electro-Plating

Novelties, interior ornamental parts, and parts requiring surface hardness, often find electro-plated finishes applicable. Such plated finishes as nickel, copper, zinc, tin and chromium are readily applied to aluminium-alloy castings provided certain simple precautions are observed. Care must also be exercised in the selection of alloy and type of plate to ensure the best results with electro-plated finishes.

The electrolytic process of oxidation or anodic treatment is finding increasing favour as a method of finishing aluminium-alloy castings. In addition to their protective value, oxide coatings possess remarkable abrasion resistance and good dielectric characteristics. Certain types of coatings are very absorbent and can be impregnated by selected substances, both for colour effects and to increase the resistance to corrosion.

It is readily seen that aluminium-alloy castings may be finished to provide a great variety of finishes to meet almost any demand. In addition to the individual finishes, combinations of these may be developed, greatly expanding the available possibilities. Methods of finishing are rather flexible, and these, as well as the operation sequence, may be varied to suit the individual conditions.

Bureau of Analysed Samples

In a report of last year's working, the managing director of the Bureau of Analysed Samples states that during the year two new standards—(No. 207) 88/10/2 gunmetal named bronze "C" and (No. 206) high-silicon and high-phosphorus cast iron—were issued. Two new standards which are in course of being analysed are 78/80 per cent. ferro-manganese steel (No. 208) and 18/8 stainless steel (No. 209).

Bronze "C" mentioned above is actually the first standard to be prepared to correspond with the B.S. specification for gunmetals, and indicates the policy decided upon after discussion with the Director of the British Standards Institution, a year or two ago, in what way that Institution and the Bureau could collaborate.

It is interesting to record that some months ago, when a sub-committee of the British Iron and Steel Federation was investigating the question of rapid reliable methods of analysis, it applied to the Bureau for a supply of several British Chemical Standard cast irons to assist it in the investigation of the combustion method for sulphur. Furthermore, its official figure for sulphur by the combustion method was published in the certificate of analyses of Cast Iron No. 206.

In view of the increased costs due to war-risks insurance, printing, packing materials, etc., it is proposed to advance prices of standards and students' samples by 5 per cent., which is regarded as a very moderate figure and will no doubt be readily accepted by users under the present circumstances.

Interest in spectro-chemical analysis for steel is growing and the directors are giving some thought to the advisability of preparing a series of suitable standard pieces.

Catalogues Received

Cupola - Glare Elimination. A four-page leaflet received from the Whessoe Foundry & Engineering Company, Limited, of Darlington, describes and illustrates the Whessoe-Whiting cupola spark arrester. The system is such that it is *force majeure* an anti-glare device, as above the charging door there is a baffle plate which deflects the current of gases to an external structure, the bottom of which terminates in a funnel leading to a settling tank. The upper portion leads the fumes back into the stack, but in the meantime a water spray has taken care of the sparks and dust. A claim for 95 per cent. of grit removal is made. Copies of this interesting leaflet are available to our readers on writing to Darlington.

Overhead Cranes. Craven Bros. Crane Division, Limited, Loughborough, have just issued an impressive booklet on overhead cranes ranging in lifting capacity from 20 to 200 tons. There are some particularly fine pictures of the crabs built into the larger sizes of cranes, and as models of neat engineering constructions they are certainly outstanding. A few special applications such as slab and plate lifting by magnet attachments and ingot stripping are included.

Roller Bearings for Machine Tools. British Timken, Limited, Cheston Road, Aston, Birmingham, 7, have issued a special catalogue devoted to the application of tapered roller bearings to machine tools. It should be worth procuring by those of our readers in charge of machine-tool foundries, as the illustrations show in the clearest possible fashion just how these bearings tie up with the general design. The catalogue runs to 32 pages and covers some dozens of different types of machine tools, most of them being illustrated by courtesy of the large manufacturers.

Cast Iron for Modern Engineering Applications

By T. TYRIE (Superintendent, B.C.I.R.A. Scottish Laboratories)

(*Continued from page* 156.)

One other important result of alloy additions is their effect on the so-called critical temperature, that is, the temperature at which the austenite formed as the first product of solidification becomes resolved into pearlite. In ordinary cast irons this change occurs at about 740 deg. C., but in the presence of alloys it becomes depressed and the change becomes sluggish so that at ordinary cooling speeds it is often delayed and occurs lower than its equilibrium temperature. The presence of alloys also reduces the critical cooling velocity, that is, the speed of cooling through the critical range which is necessary to harden the iron completely. These effects occur together, and, depending upon the amount of alloy used, have the effect of making the iron more uniform by nullifying the consequences of the differences in rate of cooling through the critical point after casting, between thick and thin sections, and of producing structures by normal cooling rates which could only be retained by most drastic quenching treatment in ordinary cast irons.

This latter effect is most noticeable in the cases of nickel and manganese, and may be illustrated by the effect of increasing nickel additions on the structure of cast iron containing 3.3 per cent. total carbon, 1.5 per cent. silicon, 0.6 per cent. manganese, 0.1 per cent. sulphur and 0.3 per cent. phosphorus as represented diagrammatically in Fig. 5. With little or no nickel as in Area 1, the austenite breaks down at the critical point to give pearlite. The small area near the origin comprises those irons which are difficult to machine owing to the presence of carbide, but since nickel is a graphitiser, this area decreases in height rapidly with increasing nickel content. The shaded areas throughout are indicative of ranges of composition which are difficult to machine.

With increasing nickel content, the pearlite becomes progressively finer and in its final stages is classed as sorbitic pearlite (Area 2). The hardness increases meanwhile, but the material remains readily machinable. With further increase in nickel, the critical cooling rate is lowered below the rate of cooling of the casting, and the iron becomes completely martensitic, passing into Area 3, and cannot be machined in the ordinary way. Still more nickel added to the iron depresses the critical point further with the result that part of the austenite does not break down, and an area is produced (Area 4) where the structure is a mixture of austenite and martensite, and ultimately by still greater nickel additions the critical point is completely suppressed and the iron becomes totally austenitic and reasonably easily machined again (Area 5). Typical structures of cast iron falling into Areas 3, 4, and 5 are illustrated in Figs. 6, 7 and 8 respectively.

Manganese produces similar results to nickel, but the carbide-forming tendency of manganese introduces difficulties, and no austenitic irons rely solely on manganese for the suppression of the critical point. The most widely used alloy addition is undoubtedly nickel, which tends to keep thin sections grey and machinable and heavy sections dense and sound. In increasing quantities it can be used to produce every metallurgical structure in cast iron, as has been illustrated, but for high-strength castings the quantity generally used is 1 to 1.5 per cent., with or without chromium amounting to 0.25 to 0.5 per cent. Chromium hardens and strengthens cast iron, but its tendency to form complex carbides more stable than iron carbide limits the proportion of chromium that may be used in castings required to be grey and machinable. It is of especial value in heat-resisting castings.

Molybdenum has a very marked influence on cast iron in that it gives refinement of grain size, graphite and pearlite, and leads to marked improvement in mechanical properties. Its effect is dual in that it toughens the matrix and exerts a slight hardening action by stabilising the iron carbide. Up to 1 per cent. these effects are pronounced, but above this limit the improvement in mechanical properties is less rapid, and hence it is seldom that more than 1 per cent. molybdenum is alloyed with cast iron. It may be used in conjunction with chromium or nickel or with both, and also gives good results in the presence of high manganese.

Copper differs from most other alloying elements in that only a limited amount is soluble in the iron, about 3.5 per cent. under ordinary conditions. Its action is mildly graphitising, and it toughens the matrix, being not unlike nickel in small amounts. The combined addition of copper and manganese, copper and chromium, or copper and molybdenum gives a decided increase in hardness and strength without loss in machinability to any appreciable extent. The ratio of these combined additions, if the chill is to be unaltered, should be 0.3 per cent. chromium, 1.4 per cent. manganese, or 1 per cent. molybdenum with each 1 per cent. copper. It is used fairly freely in combination thus in special corrosion-resisting and non-magnetic cast irons.

Aluminium as an addition to cast iron has received greater attention recently. In small quantities up to 0.1 per cent. it has been used for a long time as a deoxidiser. In somewhat larger quantities it acts as a graphitiser, but when present to the extent of about 8 per cent. begins to exert a carbide stabilising action. It is of special interest in heat-resisting cast irons.

All of these alloy additions find use either alone or in combination, the more general combinations being nickel-chromium, nickel-copper, nickel - molybdenum, nickel - chromium - molybdenum, copper-chromium, chromium-molybdenum and nickel-chromium-copper, whilst chromium-aluminium is used in the production of irons intended to be surface-hardened by the nitriding process.

Special Irons

In addition to the irons which have been considered as high-duty irons on account of superior strength characteristics, many other types of cast iron have been developed to meet the needs of industry in respect of special properties, such as hardness, wearing quality, heat resistance and corrosion resistance.

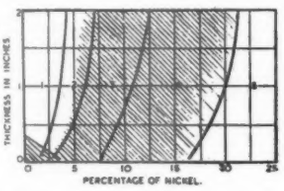


FIG. 5.—INFLUENCE OF NICKEL ON STRUCTURE OF CAST IRON CONTAINING T.C 3.3, Si 1.5, Mn 0.6, S 0.1 AND P 0.3 PER CENT. SHADING INDICATES DIFFICULTY IN MACHINING. AREA 1, PEARLITE. 2, SORBITIC PEARLITE. 3, MARTENSITE. 4, AUSTENITE PLUS MARTENSITE. 5, AUSTENITE.

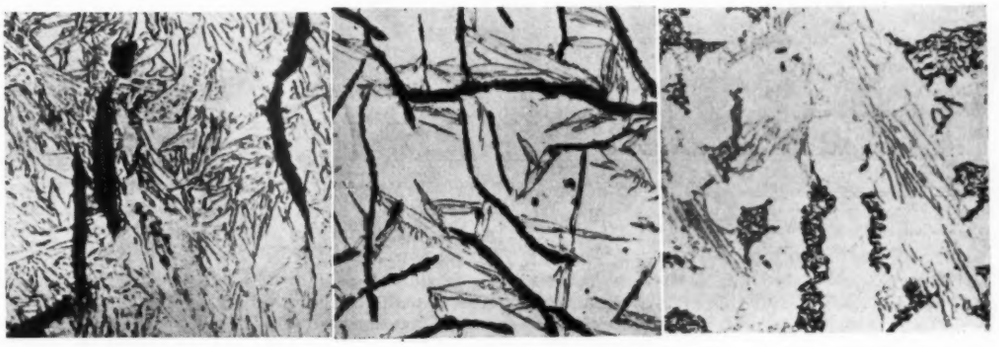


FIG. 6.—MARTENSITIC CAST IRON. FIG. 7.—MARTENSITIC-AUSTENITIC IRON. FIG. 8.—AUSTENITIC CAST IRON.

(Photomicrographs are at 200 magnifications.)

Under this class the most important group consists of the austenitic cast irons which have medium tensile strength, greatly increased ductility, a higher impact resistance, higher electrical resistance, higher thermal expansion and a lower thermal conductivity. They are not susceptible to heat-treatment. Many are made under a variety of trade names, some of which are registered trade marks, and the alloys patented. Representatives of this class are "Nomag," a non-magnetic cast iron containing nickel-manganese, "Ni-resist," a corrosion- and heat-resisting cast iron containing nickel-copper-chromium, and "Nicrosilal," a nickel-silicon cast iron developed for heat resistance.

Martensitic irons form a special group containing the structural component martensite, and are hard and difficult to machine. They find application under conditions of severe abrasion for resistance to wear. The grey martensitic cast irons have Brinell hardness numbers in the region of 450, and are used for motor-vehicle cylinders and brakedrums, and in the guide drums of centreless grinders. The white martensitic cast irons of which "Ni-hard" is typical have Brinell hardness numbers up to 650, and are used for crusher balls, milling and crushing machinery and chilled rolls.

In addition, several alloy cast irons not classified by structure are used for special applications. In the high-silicon heat-resisting class is "Silal," containing 4 to 10 per cent. silicon, whilst acid-resisting irons containing 13 to 18 per cent. silicon are also regularly produced. High-chromium cast iron containing 20 to 35

per cent. chromium is used for heat and corrosion resistance, and recently an aluminium-chromium cast iron has been developed for heat-resistance, under the name of "Cralfer." In this class also may be included nitrogen-hardened cast iron, containing 1.5 to 2.0 per cent. each of aluminium and chromium, subsequently treated to produce remarkably high surface-hardness.

Melting Practice

The type of furnace used for melting high-duty iron depends upon the limitations and capabilities of the furnace, viewed in the light of the material to be melted. Whilst most cast irons are produced in the cupola furnace, various other types are now used to yield high-duty irons either with or without alloy additions. The cupola gives carbon and sulphur pick-up due to the molten metal being in intimate contact with the coke, and there is also a loss of certain elements due to oxidation. No marked degree of superheat is possible in the cupola and temperatures seldom reach 1,500 deg. C. The lowest carbon practicable from the cupola is about 2 per cent., and at low carbon contents it is difficult to control the analysis of cupola metal.

In general, since much of the high-duty cast iron is built up from charges bearing steel scrap, it is essential to operate the cupola with higher bed coke and lower ratios of metal to fusion coke to get the temperature required, than is necessary in ordinary cast-iron production, though extremes in this are equally objectionable, in that there is a danger of increased carbon and sulphur pick-up by the metal. Furthermore, the extreme uniformity of composition essential to the achievement of regular high mechanical tests may necessitate smaller cupola charges, though less than one-tenth the hourly melting capacity of the furnace cannot be recommended, and it is advisable that the well of the cupola should be capable of holding at least one, and preferably two, charges of metal, or, better still, that a receiver of similar capacity be used.

The air furnace is used to a limited extent for making high-duty cast irons from mixtures containing scrap iron and steel, such mixtures being refined when necessary during melting. Rotary furnaces have been developed and are finding application in the melting of high-duty cast irons from special mixtures, and for duplexing or refining molten cast iron from the cupola. In a few cases the electric furnace is similarly used for both melting from the cold and duplexing. The duplexing principle is particularly valuable, in that quite apart from its utility in enabling modifications of composition to be made by the blending of ordinary cupola metal with metal of special composition to give any desired result, the effect of this addition of ordinary cupola metal to the metal melted in the rotary or electric furnace, and which will generally be of low-carbon white iron quality, is similar to inoculation in the ladle in its effect upon the structure and mechanical properties of the final mixture. Such furnaces yield higher melting temperatures, and thus give greater flexibility with the low-carbon irons, the fluid temperature range of which is narrow; furthermore they lend themselves to alloy additions and closer control of composition and temperature generally. Special cast irons for heat and corrosion resistance are in some cases melted in the cupola, but for the most part the rotary, electric or crucible furnace offers the most satisfactory method.

Foundry Properties of High-Duty Cast Iron

It is not possible to give details of foundry technique in handling high-duty cast irons since each type of casting produced and each class of iron introduces its own problems. In general, the reduction in total carbon, silicon and phosphorus contents of the metal reduces its fluidity and occasionally some difficulty may be experienced in running the castings. Usually this can be overcome by suitable gating and venting, but where these methods are insufficient or where the time required for venting is considerable, the permeability of the mould should be raised by substitution of the most open sand permissible for the one in use, having regard to the casting finish required. The increased pouring temperature of these irons may also give rise to scabbing and to considerable trouble in fettling due to burnt-in sand, which will necessitate a change in the sand or loam to more refractory materials. The lower silicon and carbon give rise to a higher solidification shrinkage and a rapid loss of fluidity and life with falling temperature, and, generally speaking, larger and more liberal in-gates will be required to ensure that the mould will be quickly filled with metal, and greater use will require to be made of risers, shrink-bobs, etc.

Heat-Treatment

Heat-treatment of high-duty cast iron is practised for three purposes:—(1) Relief of casting stresses; (2) production of easily machinable cast iron, and (3) production of irons of improved mechanical qualities. Heat-treatment for the relief of casting stresses is generally only resorted to when practical means of avoiding the production of stresses have failed, and is essentially a low-temperature anneal at 350 to 650 deg. C. for such period as will ensure complete soaking of the casting, generally about one hour for each inch of casting section, followed by slow cooling. This treatment, which has replaced the former lengthy ageing treatment, produces no change in the structure of the metal, and hence no decrease in the hardness or mechanical strength. It is particularly useful for castings where a high degree of accuracy in finished dimensions with permanence is required.

Heat-treatment for the production of easily machinable cast iron involves rather higher temperatures at about 800 to 900 deg. C. for a similar soaking period, followed by slow cooling, and it is particularly useful in the case of light castings, which by reason of damp sand or sulphur pick-up in the cupola are prone to local chilling. The decomposition of pearlite to give ferrite and graphite materially improves machinability, but brings about a considerable reduction in strength as may be appreciated by consideration of the change in structure involved, as shown in Figs. 9 and 10, which illustrate the unannealed and annealed structures respectively.

Heat-treatment following the lines adopted with steel for the production of improved mechanical properties has become increasingly used during recent years. Heat-treated cast iron combines all the advantages of cheapness and wear resistance with greater strength and toughness, and permits, moreover, of higher strength-to-weight ratios. It has been found of great value in the motor-vehicle industry, and its application in the manufacture of piston rings, valve tappets and brakedrums, etc., is a decided advance. Heat-treatment under this category involves quenching from a suitable temperature in oil or water to increase hardness, followed usually by tempering to restore, and in some cases to increase, toughness and strength.

The high-duty irons yield a greater relative improvement in mechanical properties than common irons, and alloy additions, especially nickel, manganese or molybdenum, which lower the critical temperature and quenching speed, permit of desired results with a milder quenching treatment. Tensile strength may be increased by as much as 50 per cent. by heat-treatment of high-duty irons, and certainly increases of 20 to 30 per cent. are everyday commercial possibilities. As a rule, animal or vegetable oil is to be preferred to water as the quenching medium since the latter is too drastic and may lead to cracked castings. Quenching temperatures of 800 to 900 deg. C. are employed, depending upon composition and degree of hardness desired, whilst tempering by heating in a lead or salt bath at 300 to 600 deg. C. and allowing to cool in air diminishes the extreme hardness of the quenched state, but produces improved strength and toughness to a degree depending upon the initial quenching treatment and the temperature of tempering.

With ordinary unalloyed cast irons the quenching treatment necessary to produce the desired result generally renders the iron so brittle that cracking is prevalent. For this reason alloyed irons are to be preferred as indicated above. The structural difference produced in grey cast iron by this treatment is illustrated in Figs. 11 and 12, which show the quenched, and quenched and tempered structures respectively.

(To be continued.)

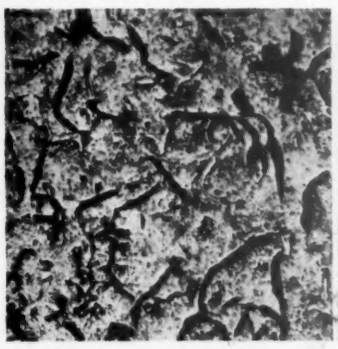


FIG. 9.—UNANNEALED GREY CAST IRON.

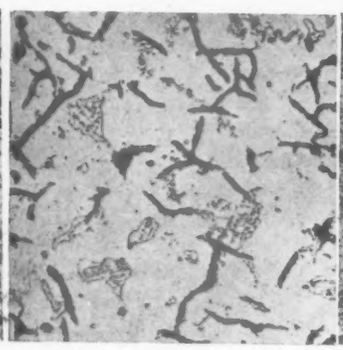


FIG. 10.—ANNEALED GREY CAST IRON.

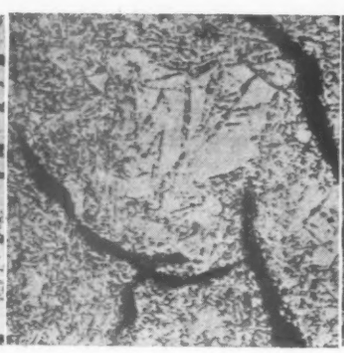


FIG. 11.—QUENCHED CAST IRON.

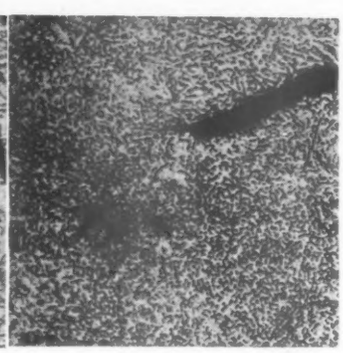


FIG. 12.—QUENCHED AND TEMPERED CAST IRON.

(Photomicrographs are at 200 magnifications.)

Analysis of Non-Ferrous Casting Defects

A USEFUL A.F.A. REPORT

This is the second progress report of the Non-Ferrous Division Committee of the American Foundrymen's Association on Analysis of Defects, and it presents a classification of casting defects, listed according to their appearance, evident to the eye, which marks castings as defective. After each classification is given a reference number which indicates the probable cause of defect. These probable causes are listed later under their respective reference numbers.

In spite of the considerable amount of study spent upon this outline, the committee feels that it is still imperfect and incomplete. Criticism and suggestions will be welcomed to the end that a more perfect and useful analysis of casting defects may be formulated.

Classification of Defects

(1) *Shift.*—A casting in which the cope and drag portions do not exactly match at the parting line.

Cause reference: A-1.

(2) *Misrun.*—A casting which lacks completeness due to the fact that the mould cavity has not been wholly filled with metal. There may be a smoothly rounded hole through the wall of the casting, or one or more extremities may be only partly filled out.

Cause references: B-2, C-2, E-2, F-2, G-2, K-2.

(3) *Cold Shut.*—The casting appears to be cracked, but on closer examination it is found that the metal has failed to join or coalesce along the line of the apparent crack. In some cases, partial coalescence leaves a line of weakness which later does crack.

Cause references: B-3, C-3, D-3, E-3, F-3, G-3, K-3.

(4) *Crush.*—A casting showing deformation, apparently due to displacement of sand when the mould was closed.

Cause references: A-4, B-4, D-4.

(4*a*) *Swell.*—A casting showing deformation on cope side due to displacement of sand by pressure of metal.

Cause reference: B-4.

(5) *Variation in Wall Thickness.*—A casting which at one or more points shows more or less metal than is called for by specification. It may be uniformly too heavy, uniformly too light, or may be too thick on one side of a cored cavity, too thin on the other.

Cause references: A-5, D-5.

(6) *Sand Wash.*—The casting may have rough lumps of metal at some points on its surface or may exhibit rounded corners which should be sharply defined. At other points there will be roughly granular depressions or holes.

Cause references: A-4, D-6, E-6, H-6.

(6*a*) *Scab.*—A rough spot, usually on a thin-walled portion of the casting, the wall being slightly thicker than normal at this point, porous and containing sand grains.

Cause reference: D-6*a*.

(7) *Sand Blow.*—The casting shows an unnaturally smooth depression at one or more points on its outer surface.

Cause references: D-7, E-7.

(8) *Core Blow.*—The casting shows a smooth depression, sometimes black, sometimes golden, on an inner surface where there is a cored cavity or, often, a gas pocket in some heavy portion of the casting above the level of the cored cavity.

Cause reference: H-8.

(9) *Burning into Sand.*—Certain outer parts of the casting have a rough, sandy appearance as if the metal had penetrated freely between the sand grains, some of which are completely surrounded and enclosed in the outer wall of the casting.

Cause references: E-9, F-9 & 10.

(10) *Burning into Cores.*—Sometimes a rough, sandy inner surface, similar to the penetration of metal into green sand, but more commonly in the form of metal fins penetrating into the core and containing trapped grains of core sand.

Cause references: F-9 & 10, H-10.

(11) *Sand Sticking in Cored Cavities.*—Even when there is no apparent "burning-in," castings having intricate cored passages, or cavities of small dimension and relatively inaccessible, sometimes show a tightly adherent sand coating.

Cause reference: H-11.

(12) *Surface Imperfections.*—Castings otherwise of apparently perfect quality sometimes have surface defects which may be of importance on the ground of appearance only. In other cases, these apparently superficial defects are indicative of more deep-seated ailments. The following items, 12*a*, *b*, *c*, *d* are listed as typical.

(12*a*) *Wormy Surface.*—The surface of the casting, usually in the vicinity of the gate, shows irregular depressions, shallow but elongated, similar in appearance to worm tracks. These depressions are often filled with a deposit of zinc oxide, and are sometimes accompanied by a very poor fracture.

Cause references: C-12*a*, F-12*a*.

(12*b*) *Surface Stains.*—The surface of the casting shows a black discolouration of varying size and shape.

Cause reference: H-12*b*.

(12*c*) *Tin or Lead Sweat.*—The surface of the casting is more or less covered with a thin layer of white metal. In the case of lead, the sweat often occurs in spots or lumps, sometimes of considerable thickness.

Cause reference: F-12*c*.

(12*d*) *Rough or Pitted Surface.*—Although the casting does not show evidence of sand washing or scabbing, the surface is rough or exhibits an occasional angular pit, sometimes so deep as to leave an objectionable scar on a finish-machined surface.

Cause references: E-12*d*, F-12, K-12.

(13) *Solid Inclusions.*—With a fracture which otherwise appears to be good, the walls of the casting contain particles or small chunks of non-metallic substance, or separate pieces of metal not coalesced with the body of the casting.

Cause references: F-13, K-13.

(14) *Shrinkage Cracks and Cavities.*—With a fracture otherwise apparently good, the casting shows at one or more points a crack or cavity where the metal has pulled apart while it was still in a plastic condition. The walls of the shrinkage cavity are usually tarnished to a colour which varies from orange to dark brown.

Cause references: C-14, G-14, L-14.

(15) *Weak or Discontinuous Structure.*—The fracture of the casting is bad at practically all points. Commonly the structure is dendritic with minute fissures between the large crystals, which are tarnished to an orange or brown colour. Sometimes, with crystals of more normal size, the fracture is of a loosely granular appearance rather than fibrous. Other varieties of abnormal fracture may be encountered.

Cause references: F-15, G-15.

(16) *Gas Porosity.*—This condition, sometimes called sponginess, is marked by small but clearly discernible gas bubbles, usually segregated near the surface, but underneath the skin, of heavy sections of the casting. The cavities are approximately round and bright, free from tarnish.

Cause references: F-16, G-16, L-16.

Classification of Probable Causes of Defects

A—Condition of Pattern, Flask, Core Box, etc.

(1) Loose dowel pins and inaccurate fitting of cope to drag will result in shifts.

(4) If the core print is too small for the core, a core crush will result.

(5) Worn core boxes will cause the core to be too large, resulting in too thin a casting wall. If the pattern makes too large a core print, the core may shift or float, resulting in a variation in metal thickness.

(6) In the case of a core crush, a sand wash is also likely to develop.

B—Position of Mould.

(2) The mould must be so placed that the molten metal in the sprue will be substantially above the level of the highest casting, in order that the hydrostatic pressure will be sufficient to prevent misruns.

(3) A cold-shut may result from failure to take precaution B-2.

(4) The weights used must be heavy enough to prevent swells but not so heavy as to cause a crush.

C—Gating.

(2) The gates leading to the individual castings in the mould must be large enough to permit free flow of the metal. Otherwise, misruns may result.

(3) Restricted flow of metal may also cause cold-shuts.

(12*a*) "Wormy" surface near the gate is sometimes due to inadequate gating.

(14) Shrinkage cracks may frequently be due to improper gating or to the lack of risers where needed.

D—Moulding Practice.

(3) A slight crush at the parting line may force a fin of sand into the metal, producing an appearance very similar to that of a cold-shut. A true cold-shut may also be due to insufficient venting.

(4) Crushes are usually due to carelessness on the part of the moulder.

(5) Variation in wall thickness may be caused by uneven ramming.

(6) Too light ramming may result in sand wash.

(6*a*) Too heavy ramming may result in scabs because the mould face is so dense as not to have room for expansion when exposed to heat of metal.

(7) A sand blow may be caused by insufficient venting.

E—Quality and Condition of Moulding Sand.

(2) If the sand is too wet, it may chill the metal excessively and cause misruns.

(3) Wet sand, by chilling, may make the metal sluggish and result in cold-shuts.

(6) If the sand has insufficient bond, or is too dry, the mould may be weak, tending to permit sand wash.

(7) Wet sand, or sand with too low permeability, is likely to result in sand blows.

(9) Sand which is too coarse, too dry, or has too high a permeability, may permit the metal to burn-in.

(12*d*) Coarse sand or dirty sand which contains fragments of cores or metal, will cause the surface of the casting to be rough or pitted.

F—Quality of Molten Metal.

(2) Sluggish metal may cause misruns as a result of contamination by impurities. These are most likely to be oxygen or sulphur, present in the metal as charged into the furnace, or by contamination from fluxes or furnace fuels.

(3) Cold-shuts are also influenced by impurities in the metal, as stated in F-1.

(9 & 10) Excessively fluid metal resulting from the use of too much phosphorus, or from the presence of such impurities as aluminium and

silicon, is likely to burn into moulding sand and cores.

(12*a*) In leaded alloys, very small percentages of silicon (0.03 per cent.) or aluminium are likely to produce a "wormy" surface.

(12*c*) Contamination by silicon also tends to produce lead sweat. Silicon may have been present in scrap used in the furnace charge, may be picked up from silicon carbide in a furnace lining or, in the electric furnace, may be produced by the action of oil, electrode smoke or other carbonaceous material.

Lead sweat is most likely to result from too low a proportion of tin in the alloy. With lead as high as 10 per cent., the percentage of zinc also should be maintained at 6 per cent. or above.

It is possible that the presence of an excessive amount of gas (as hydrogen, for example) dissolved in the molten metal may force lead to the surface of the casting.

(12) Very fluid fluxes cannot be skimmed readily from the surface of the metal and are likely to be carried into the mould, resulting in surface imperfections on the casting.

(13) Solid inclusions in the walls of the casting, apparent in the fracture, are also often due to "soupy" fluxes and slags.

(15) A coarse, dendritic, discoloured fracture is most commonly due to the presence of silicon or aluminium in the alloy.

(16) Gas porosity frequently results from the presence of hydrogen or sulphur dioxide, absorbed by the molten metal from the furnace atmosphere. Hydrogen is often present as a result of water or oil in the furnace charge.

G—Pouring Temperature.

(2) Metal which is sluggish, because it is too cold, will often cause misruns.

(3) Cold, sluggish metal is commonly responsible for cold-shuts.

(14) If other conditions are correct, shrinkage cracks and cavities may safely be charged to too low a pouring temperature.

(15) Too high a pouring temperature will result in a coarse, weak crystalline structure.

(16) Gas porosity is often due to too high a pouring temperature.

H—Quality and Condition of Cores, Parting Powder and the Like.

(6) An overbaked core will be weak on the surface and may result in core-sand wash.

(8) Insufficient baking may cause a core blow.

(10) If the cores are baked too rapidly, or if the amount of binder used is not properly proportioned, they may crack and permit metal fins to form. Overbaking may result in burning-in.

(11) Sticking of core sand in inaccessible cored passages may be prevented by the use of a rubber core wash.

(12*b*) Surface stains are sometimes due to the excessive use of flour or molasses.

K—Skimming and Pouring Practice.

(2) If pouring is interrupted or slackened before complete, a misrun may result.

(3) A fragment of oxidised metal from the lip of the pouring ladle will sometimes lodge in the wall of the casting, producing an appearance similar to cold-shut.

(12) Faulty skimming or careless pouring may result in fragments of slag or oxidised metal entering the mould and lodging on the surface of the casting.

(13) Solid inclusions in the body of the casting may be caused as indicated in K-12.

L—Design of Casting.

(14) The casting design should be such as to avoid heavy sections and light sections in close proximity. If this is not possible, a fillet of ample radius will tend to prevent shrinkage cracks at corners.

(16) Without such fillets there will be a tendency to pour at such high temperatures as to result in gas porosity in heavy sections.

Radiographic Applications in the Foundry

Writing on "Radiographic Development in the Casting Industries" in "Metals and Alloys," MR. CHARLES W. BRIGGS (Technical Adviser, Steel Founders' Society of America, Cleveland) states that the foundry industry is not opposed to the establishment of sets of radiographic standards that are fair in their treatment of the subject. His view is that the industry welcomes them, providing the standards are prepared for castings of a specific application, such as certain U.S.A. Navy standards which are limited to steel castings intended for steam-pressure service. The reason that standards of this type are willingly accepted by foundrymen, says Mr. Briggs, is that they set up standards which may be observed and used as guides. This is quite different from some vague ideas on rejection limits that repose in the minds of the purchasers of castings or their authorised inspectors. The presence of standards sharply defines the situation.

Appended are extracts from the article dealing with such matters as the interpretation of radiographs, and the value of radiography applied to designing and production.

Radiographic Interpretation

One of the most serious drawbacks in the adoption of radiographic methods by casting producers has been the fear of radiographic interpretation. It was felt that minor discontinuities in unimportant sections were given as much consideration as the more important disclosures in critically stressed sections. The situation involves more than fear of the possibility of having this come true, for in some cases it actually happened. These situations resulted largely from the fact that the operating conditions and requirements applicable to the various casting members were not known to the inspectors or to the purchasers.

Such conditions have led casting producers to use caution in accepting unqualified orders calling for castings subject to radiographic examination. Orders of this type mean that the purchaser may radiograph any and all parts of the casting and perhaps reject the casting for some minor defect present in an unimportant section, such as the tie-in sections which carry no important stresses and which may be so designed that their factor of safety is extremely high.

To prevent occurrences of this type, the foundry management should request that the consumer submit marked drawings which designate the places that will be subject to radiographic examination. The thought underlying such a request is that marked drawings will help the foundryman materially in planning the production of the job. It will enable the operating department to provide for desirable metal feeding and in many cases reduce the use of inserts; in fact, the mould may be produced in a manner differing entirely from production procedures wherein no information as to casting requirements of important or highly stressed areas is given.

The foundry management likewise desires to discuss with the purchaser at the time the order is received the subject of interpretation of the radiographic results, since he desires to know if the purchaser has a set of standards that are reasonable and mutually satisfactory. If the purchaser has no standards, the casting producer will probably suggest that rejection be determined after consultation.

There are some who believe that the product of the foundry industry is seldom, if ever, free from defects. In many cases, they have based this opinion on the continued appearance in the technical Press of radiographs of defective castings. The fact that the authors usually state that the illustrations presented should not be used as an indication of the quality of castings in general apparently makes no impression.

It so happens that the radiographic methods are well adapted to the non-destructive examination of castings. Welded construction is likewise adaptable to this type of investigation, and it is believed that the technical literature contains as many reproductions of radiographs of defective welds as it does of castings. Other metal forms have their share of defects also. It so happens that other methods of non-destructive testing are more adaptable, such as in the location of laminations and seams in plate and fabricated shapes.

Radiography an Aid to Designers

Foundrymen have great hopes that radiography will be of material aid in pointing out to designing engineers and purchasers in general that poor design is responsible for a large percentage of the castings that prove defective. For many years foundry engineers have requested that designers make their proposed designs more castable. They have continually suggested that the design engineer consult with them while the design is in the formative stage. If co-operation between designer, purchaser and foundryman existed at that time, many difficulties and much dissatisfaction could be avoided. It is believed that radiography will tend to bring about such co-operation because producers are being confronted with radiographs of castings which are not so designed that it is possible for the foundry to secure the quality of castings that the designer intends to have.

The foundryman to-day is also insisting to a greater extent that poor design features of castings be discussed with the purchaser. He realises that the purchaser will reject a defective casting as shown by radiography, even if the designer has designed it so that it could be nothing else but defective. And even though the foundryman can convince the purchaser that poor design is responsible for the defect, the foundryman nevertheless has a defective casting on his hands.

Thus, there is a strong expectation that with the progress of radiography in the casting industry will come the appreciation by designers of more tolerant designing, since radiography makes it so easy for them to see the results of their handiwork.

If a casting be designed properly, the percentage of defects to be found resulting from manufacturing operations is low. Proof of this statement may be obtained at any foundry where a casting which has been standardised as to design and production details is being made regularly. Radiograph after radiograph will be found to be flawless.

Radiography an Aid in Manufacturing

Radiography is of value to many foundrymen as an aid in establishing the manufacturing procedure of a casting. A pilot casting may be completely radiographed in order to check on casting design and production methods. In this manner, changes can be made to the pattern or mould construction so that the next casting will be a perfect job. This prevents the repetition of a defect in a number of castings, all of which may be rejected.

It is believed that radiography is bringing about greater understanding of the service requirements of a casting. More attention is being given to the highly stressed areas of castings. The result of this has been that defects which previously may have caused rejection are now being repaired and accepted, since the sections in which they occur are not vital ones. Also, purchasers are more willing to repair castings when they can re-radiograph the casting and observe the condition of the repair. The Bureau of Engineering of the U.S. Navy has found that, because of radiography, it could authorise the repair of certain castings which would have been rejected before the advent of radiography.

Welding as a Substitute for Casting*

By S. F. DOREY, D.Sc.

The object of this Paper is to indicate the progress that has been made in the substitution of welded mild steel parts for ferrous castings; for convenience these may be termed "weldings." Mention will also be made of the advantages claimed on behalf of weldings over castings, and the author will deal with the main factors on which the production of sound and efficient weldings depends. Typical examples of weldings used in different branches of engineering will be described.

For certain parts in engineering construction cast iron has for long been regarded as the most suitable material from both the strength and economic points of view. In recent years, however, the development of fusion welding processes has led to the increased use of mild steel for parts where cast iron was formerly employed. A feature of this substitution is, of course, that a considerable reduction in scantlings can generally be adopted, and in consequence a proportionate saving in weight is obtained.

In land installations the weight factor may not be important, whereas in marine work a few tons saved in the weight of the machinery installation allows a corresponding increase in cargo carrying capacity, or in bunker capacity, or both. Again, progress in marine machinery installations, especially for the large liner, has invariably necessitated an increase in the number of auxiliaries to be used for a diversity of purposes. The added weight entailed can to some extent be offset by the use of weldings instead of castings for some of the parts involved.

It is sometimes claimed on behalf of weldings that first cost is less than for castings, and whilst in certain instances this may be true, it should not be the primary reason for the adoption of welded parts. In castings of simple design required in large numbers, a small number of patterns can be used over and over again, and in consequence first cost will probably be less than for welded parts intended for the same purposes. Against this it may be claimed for welding of larger parts that there is a saving of time not only on patterns but possibly also on rejected castings; there are also reduced machining costs.

Cases for Economic Substitution

In the author's view it is only necessary to consider the substitution of weldings for castings in the following circumstances:—(1) When it is important to restrict weight to a minimum, and (2) when it is considered that a better or more suitable article can be made by the use of welding. Both of these conditions can be met not only by the use of lighter scantlings, but also by the more efficient distribution of material obtained by fabricating the part in mild steel.

To ensure a sound casting it is necessary to avoid as far as possible large variations in the thicknesses of the various components, whereas in a welding there is no limit to the extent of the variations which can be allowed, and material can be distributed in such a way as to afford the best resistance to service stresses. Another advantage in welding which is of special interest to the manufacturer, especially in the case of certain large structures which might otherwise be cast, is the ease with which modifications in design can be effected during actual manufacture, should any modification appear to be desirable.

The main advantages of mild steel over cast iron are its considerably higher elastic modulus and its better resistance to the effects of temperature. For the same strain the ratio of the permissible stress in mild steel as compared with cast iron is approximately 2:1. From the practical design point of view, however, it would be more useful to note that for the same conditions of loading the modulus of the section in mild steel need only be about one-half of that in cast iron. It is this factor, of course, which is responsible for the reduction in weight obtained.

Reduction in weight may not, however, follow in the same ratio as the elastic modulus, for the reason that in substituting welded mild steel for cast iron the question of rigidity may arise, especially in machinery bedplates and entablatures. Rigidity is an inherent quality of cast iron, and in this respect it is superior to mild steel. In a welded mild steel structure, therefore, it is necessary to ensure adequate rigidity by adopting a suitable and efficient system of webbing and bracing. The incorporation of the required stiffening components sets a limit to the extent of weight reduction that might otherwise be possible were it only necessary to consider the strength properties of the structure. Despite the necessity of providing for adequate rigidity, savings in weight of between 20 and 40 per cent. over cast iron are possible.

As an example of a part in which rigidity and resistance to crushing forces are important, reference might be made to a welded mild steel base for a 750-ton keel bending press, installed early in 1939 at Chester, Pa. The weight of this base was 39 tons, as compared with 48 tons, the weight of its cast-iron predecessor which had broken. This welded steel base was 27 ft. by 9 ft. by 4 ft. 7 in. in depth, and whilst it was about 20 per cent. lighter than the previous cast-iron bed, it was estimated to be considerably more rigid by virtue of a heavy system of webbing comprising three longitudinal webs, the outer two being steel plates 12 in. in thickness, the central one a 2-in. plate, with transverse vertical diaphragms 1 in. in thickness and spaced 24 in. apart, tying all three webs together. The top and bottom plates were 3 in. in thickness.

It cannot yet be said that in this country there has been an extensive change from cast iron to welded mild steel. The trend in that direction, however, is apparent, and it is better, from the point of view of reliability and safety, that the transition should be slow and gradual, allowing time for the accumulation of experience.

In marine installations, parts now commonly made in welded mild steel are main and auxiliary engine bedplates, pipes and pipe flanges, oil and water heater bodies, condensers, evaporators, steam traps, superheater headers, eduction pipes, turbine cylinders and gear cases, armature hubs and stator frames, and bedplates for such important items as windlasses, capstans and winches. In addition, sundry valves, brackets and pedestals, which were formerly made of cast iron, are now frequently manufactured in the form of weldings.

The development of welding owes a great deal to the electrical engineer, and accordingly it is perhaps to be expected that the greatest progress in the application of electric welding processes has been made in the electrical engineering industry. In the construction of electrical generating plant, welding is now common practice in the building of stator frames, armature hubs and spiders, and bedplates. Other electrical apparatus, such as transformer and switchgear tanks, and the vacuum type of container, are specially suitable for welding from the point of view of oil-tightness and resistance to internal pressure.

One of the main advantages of welding over casting is that the designer is not tied to a range of standard castings that might be available. This may be of special importance in such items as pedestals, yokes, switchgear, and hubs and bedplates for generating plant, where each job can receive individual consideration, and special features can readily be incorporated in the welding which would otherwise be prohibited for a casting for which standard patterns would be used.

It is often said that, when replacing a casting by a welding, the designer should forget all about the shape of the casting and design purely from considerations of welding technique. However excellent this idea may be in theory, the fact is that in designing a welding it is usual to have very much in mind the shape of the cast prototype. When questioned as to the basis for a particular welding design, draughtsmen have admitted, rather reluctantly, that they have had before them the design of a similar casting and have merely reduced scantlings, omitted superfluous material, and placed components, such as ribs and stiffeners, precisely at those positions which common sense and, to some extent, calculations have indicated. This surely is the rational procedure to adopt when replacing a casting by a welding, for it takes full advantage of past experience which has proved a particular "shape" to be the most suitable for the function it is intended to fulfil.

Factors in Design of Weldings

There are, however, certain general principles which should, as far as possible, be used as a guide in the design of weldings, namely:—

(1) Make full use of standard rolled and pressed shapes and sections.

(2) Avoid abrupt discontinuities in design and keep welds clear of positions where stress concentrations may occur in service, or where stresses may be of complex character.

(3) Restrict the size of welds to a minimum consistent with strength and efficient attachment of the parts joined.

(4) Avoid placing two or more heavy welds so close together that their shrinkage when cooling will impose severe tensions in the plate material between them.

(5) Keep in mind the question of accessibility for welding and for subsequent inspection. Further, important welds should be made in the horizontal downhand position.

To summarise the most important examples of welding replacing casting, the following appear to be representative:—

In Marine Engineering Plant—
- Bedplates and columns.
- Condensers and evaporators.
- Heater shells.

In Electrical Engineering Plant—
- Bedplates.
- Stator frames and armature hubs and spiders.
- Low-pressure turbine cylinders.
- Transformer tanks.
- Switchgear.

General—
- Gear cases and gear wheel centres.
- Bearing brackets of special design.
- Rolling mill parts.
- Heavy machine-tool frames.

Lest it be inferred that the author visualises the time when cast iron will be a thing of the past, it must be stated that for quantity production of low-stressed parts of standard design the ironfoundry will always offer the most economic and satisfactory results. It is thought, however, that cast iron will be used in a decreasing degree for the manufacture of those important parts of engineering plant mentioned above.

It should be acknowledged that this is a steel age, and steel, either cast forged or welded in

* Extracts from a Paper read before the Institution of Engineers and Shipbuilders in Scotland on February 20. The author is on the staff of Lloyd's Register of Shipping.

the plain carbon or alloyed condition, is the primary material in engineering construction to-day. Accordingly, it is necessary to differentiate between iron castings and steel castings when discussing the relative merits of casting and welding. A steel casting can exhibit the highest qualities in strength, toughness and resistance to corrosion and high temperatures. With the addition of alloying elements, a range of properties can be obtained designed to meet the variety of service conditions of stress and temperature to be found in modern engineering plant.

The substitution of weldings for iron castings may, therefore, in certain circumstances be regarded as a desirable proposition, whether from the point of view of improvement in the quality or suitability of the product, or simply on account of the economy in production costs. But where steel castings are concerned, welding has very definite limitations, mainly because (1) the weldability of certain alloy steels is still in the experimental stage, and (2) for certain parts of special design intended for high internal pressure, accessibility for welding may be too difficult to ensure sound welding. In this connection highly stressed welds should always be made from both sides of the joint.

Composite Fabrications

It has been found that for certain parts of machinery installations a useful combination of welding and steel castings can be employed. Thus in steam generators, such as the Velox and Loeffler boilers, tubes and elements are welded to cast steel headers. In certain turbine cylinders and gear cases it has been found desirable to incorporate cast steel components, such as bearing housings, which are welded to the mild steel structure. The main bearings of welded bedplates for reciprocating engines are sometimes housed in cast steel pedestals. An example of this method is a welded bedplate for a Sun-Doxford oil engine now building. Thus if a forecast were to be made of the future trend in materials used in engineering construction, it might be said that present tendencies indicate an increasing use of carbon and alloy steel castings and forgings in conjunction with welded components, and a more extensive substitution of weldings for iron castings.

This discussion would be incomplete without a reference to those factors in fusion welding which ensure the soundness of the finished article, and provide the basis for confidence in the use of weldings for parts of primary importance in machinery installations. The main defects in fusion welding which it is necessary to guard against are bad penetration, inclusions (gas or slag), undercutting at the sides, cracks and distortion. All these defects might be successfully avoided and a weld produced which is yet deficient in strength properties. It is necessary, therefore, to provide safeguards such as the adoption of (1) welding methods which aim at precluding the above defects, (2) inspection methods which will reveal such defects, and (3) tests which will check the strength properties of the welds.

In recent years welding has been exposed to a degree of inspection and testing, both in research laboratories and workshops, which has seldom been applied to other constructional processes in the past. This has been due partly to the somewhat stubborn prejudice which has persisted, mainly in Great Britain, but more especially to the fact that fusion welding processes are the result of scientific development in several spheres of industry, namely, metallurgical, electrical, chemical and mechanical. Welding to-day, therefore, owes its development to the combined efforts of scientific thought in a variety of important industries. It was not unnatural that each of these industries concerned itself in the main with those problems of welding research that were peculiar to its own interests. In the absence of co-ordinated effort in research work, the result was that a good deal of overlapping took place, and as no central directive influence was brought to bear on industrial and academic research programmes, the problems involved were apt to become confused in a mystery which aggravated rather than dispelled prejudice.

Co-ordination of Research

In May, 1935, the Symposium on the Welding of Iron and Steel, organised by the Iron and Steel Institute with the collaboration of other leading technical institutions, focused attention on the need for co-ordinating research in welding. This led to the formulation of a wide and comprehensive schedule of research work which was placed under the direction of an authoritative Research Committee of a reconstituted Institute of Welding. Since that time much useful work has been done, and welding can now be regarded as an acceptable method of construction, having in many cases definite advantages, both in economy and efficiency, over old-established practices in the manufacture of engineering plant. Thus, it is possible to approach the subject of welding without suspicion and to consider the main conditions involved in the above-mentioned safeguards. Welding methods which aim at precluding the defects previously mentioned embrace the following factors:—

(1) Use of suitable materials, including electrodes.
(2) Use of efficient welding plant and tools.
(3) Employment of experienced welders.
(4) Provision of adequate supervision over the welding work.
(5) Efficient heat-treatment in certain instances.

These factors may be further sub-divided, but it is not proposed to do more than refer to them in general terms in this Paper.

The question of weldability of materials becomes of increasing importance in the sphere of alloy steels. For ordinary commercial mild steel there is no serious problem in weldability. There is, however, a very wide range of welding electrodes available to-day and not all are suitable for the highest class of work. Electrode makers are usually careful to discriminate between the various qualities of their products according to the purpose for which the welds are intended, or to the specification which it is required to meet. Nevertheless, it is suggested that for important welded work a very careful selection of the electrode should be made.

It is thought that the most sensitive test for grading electrodes, as well as for judging the standard of workmanship, is the X-ray examination. It is, of course, essential to interpret X-ray photographs with intelligence, and with a full appreciation of the various factors in radiographic technique which affect the results obtained. For the selection of an electrode, the test plates should be prepared by one experienced welder, and the X-ray negative corresponding to the electrode selected should thereafter be regarded as the standard for assessing workmanship using that particular electrode.

The Human Element

In the employment of experienced welders for important work, mention must be made of that bogey in welding, which is so often emphasised by "those of little faith," namely, the human element. The human element in welding, admittedly important, is no more important than the human element in many other spheres of engineering construction. Good welding requires a skilled workman, and the best work calls for experience and a high degree of competence. Slag inclusions and undercutting are typical defects that come under the welder's control provided, of course, that he is using an electrode which is known to produce sound and homogeneous welds. In oxy-acetylene welding the correct mixture of the gases in the burner is under the control of the welder, who should be able to detect slight changes in the characteristics of the welding flame which are likely to affect the resultant quality of the deposited weld metal.

An experienced welder, by virtue of his experience, should have a practical knowledge of the effect of the welding heat on the parts being welded. Accordingly, he should be able to arrange the sequence of his welding and the direction of deposition in such a way as to have the least detrimental effect either in distortion or cracking, or both. Such details as size of electrode, amperage, and speed of welding are also factors with which an experienced welder is intimately concerned.

These and other problems of welding technique are also the concern of the welding supervisor, and it is desired to emphasise that the employment of experienced welders, together with efficient supervision, are of first importance in ensuring sound welds. All these details may be grouped under the heading of "Procedure Control," which, in the author's view, is a more effective safeguard than any testing methods that may subsequently be employed.

Heat-Treatment of Welds

The question of the need for heat-treatment of welded parts is one which, in this country, is as much influenced by the facilities available for heat-treatment as by the individual technical merits of the case in question. This is, of course, an illogical position, because the necessity for heat-treatment has nothing whatever to do with the facilities available. Unimportant machinery parts, or parts of simple design and intended for low working stresses, may safely be put into service in the "as-welded" condition, but, in the author's view, heat-treatment is of such value as a safeguard that it should be adopted wherever possible. It is of no credit to industrial efficiency in this country if adequate heat-treatment facilities are not available.

Residual stress due to the heat effect of welding may lead to cracking in the welds, or in the parent plate. Such a stress is in reality a hidden defect of unknown magnitude. Research work is in progress with a view to analysing the magnitude and direction of residual stresses caused by welding, and sufficient work has already been done to indicate that such stresses may occur, and may in some instances attain a value approaching the yield point of the material. On the other hand, sometimes the residual stress actually exceeds the yield point, and where this occurs either a crack is formed or the metal yields without cracking and thus relieves itself of stress. Inspection of finished welds should therefore be mainly directed towards the discovery of cracks.

In order to avoid distortion, much welding nowadays is carried out under severely restrained conditions, such as obtain when the components are rigidly held in jigs. Even in the welding of parts under "free" conditions it is seldom possible to allow complete freedom of movement throughout the entire welding operation. For accurate work jig welding is generally recommended, and this means welding under restrained conditions. By using a ductile weld metal, yielding may take place under such conditions, and the part will be left comparatively free from residual stress. It must be appreciated, however, that in the present state of knowledge on the subject it is not possible to say with certainty that a welded part which has not been heat-treated is free from residual stress.

At the same time, the residual stress problem also exists in relation to castings. Shrinkage cracks in castings are not an unknown phenomenon, and no one would think of putting an important steel casting into service without subjecting it to an efficient annealing treatment. Similarly with weldings, it should be standard practice to apply a stress-relieving heat-treat-

ment in every case. The author has found that this practice is more general in the United States of America than in this country, and it should be pointed out that welding is a much older established manufacturing process in America than in Great Britain.

Preheating

Preheating is not considered necessary for the larger types of mild steel structure. In certain cases, however, it may be advisable to preheat locally as an additional precaution against crack formation and high residual stress, as, for example, in attaching heavy flanged parts to cylindrical shells where complex stresses are likely to be set up. Care must be taken not to prolong this treatment, which will tend to coarsen the granular structure. In alloy steels, however, weld shrinkage and crack formation due to air-hardening can be eliminated by preheating, but here careful control is necessary. Temperatures varying from 200 to 600 deg. Fah. have been successfully employed.

Two other "safeguards" have been mentioned, namely, inspection and testing. It has already been stated that the inspection of a finished weld should mainly be directed towards the discovery of cracks, and for this purpose a magnifying glass is specially useful. Where reliance is to be placed on visual inspection for cracks, it is good practice to shot-blast the part after heat-treatment. One American firm which the author visited recently applies heat-treatment and shot-blasting to the bedplates and columns of a well-known type of heavy oil engine. The firm's welding has been proved to be of the highest class, yet they consider this practice to be an essential safeguard against failure. Neither heat-treatment nor shot-blasting are common practices in Great Britain for welded structures of this type. In special cases, such as gear casings, valves and steam pipe fittings, shot-blasting is particularly desirable for removing the mill scale and cleaning the welds.

Detection of Cracks

Crack detection has been placed on a scientific basis by the development of magnetic and X-ray methods. Magnetic methods include two main forms, one in which the article under test is magnetised and sprayed with a colloidal fluid of powdered iron, and the other which necessitates the use of instruments for measuring magnetic potential drop or flux leakage between two points. In the latter the ratio of the reading across a weld to the readings on the parent metal on either side of the weld is a measure of the quality of the weld, since a defective weld containing a crack, or other serious discontinuity in metallic structure, will show a higher ratio than a good weld of the same type and materials. The former magnetic method, however, is generally preferred, as it is both simple and direct. The iron particles form up along lines corresponding to the breaks in the magnetic flux lines caused by cracks and voids, and the presence of such defects is readily observed. The X-ray method is more expensive, but, as has already been stated, it is invaluable where a high standard of welding work is desired.

It should be appreciated that few castings are free from the defects commonly associated with welds. Shrinkage cracks, slag and gas inclusions and "draws" would often be found in a casting were it subjected to the searching examination more often imposed on welds. It is to the credit of those responsible for high-class welding that their work will stand up to inspection methods which would normally be considered too severe to apply to castings or forgings.

A final safeguard is the testing either of the weld itself or of typical representative test samples. The main tests applicable to the welding are the hydraulic test in the case of a pressure vessel, and a proof load test in the case of a structural part. Both are excellent methods for reassuring the inspecting authority, and for creating confidence in the soundness and strength of the welding. It is not, however, always possible to apply such tests, and reliance must therefore be placed on the results of mechanical tests on samples which are representative of the part concerned. This entails the preparation of separate test samples, which should be made under precisely the same welding conditions as the part they are intended to represent. It is sometimes possible to incorporate the test samples in the actual welding, much in the same way as a test-piece is cast integrally with a casting. The tests may include tensile, bend and impact tests, and in special cases fatigue and corrosion tests. Generally, the tensile, bend and impact tests will suffice, and the results obtained should not be inferior to those for the parent material. No system of testing of representative samples can in itself be regarded as a complete guarantee of the welding work, and for this reason the importance of efficient procedure control during construction should be emphasised.

Much more could be written concerning details of inspection and testing, but the author is confined to a discussion on the subject of welding in its relation to casting as a method of manufacture for parts of engineering plant. Sufficient has been said to indicate the relative merits of the two processes, and whilst the subject is one which lends itself to speculation and imagination so far as the future trend is concerned, it is considered that the technical advantages of welded mild steel over cast iron are definitely established for structural components, but will always be qualified by consideration of the economic factors, which will in many cases favour the use of cast iron.

Further, it would be unfair to close this discussion without acknowledging the progress that has been, and is being made, not only in the production of cast iron but also in ironfoundry practice. Some of the special close-grained cast irons now available exhibit qualities, such as resistance to abrasion, which could not be obtained with mild steel, but even in this sphere it is necessary to bear in mind the methods for providing hard surfaces by applying special wear-resisting metals by gas welding.

In conclusion, it would be well to state that there appears to be no ground for suggesting any serious competition between welding and iron casting. Each process has its legitimate sphere of usefulness and scope, and if in some instances these overlap, as they do, then choice will be guided by the well-defined merits of either process for the particular application in question.

Cast Camshafts

METHODS OF PRODUCTION

DR. H. JUNGBLUTH, writing in "Technische Mitteilungen Krupp," claims that a catalogue issued by the Anna Steel Foundry in 1902 in connection with an exhibition held in Düsseldorf showed that they were prepared to cast locomotive crankshafts in 31-tons tensile steel. He gives the following information on the casting of camshafts. The composition ought to be such that the shaft is soft and the cranks hard. To ensure this he gives the following alternatives:—

(1) Cast the camshaft with some hard and easily machinable alloy, the cranks to be cast against a chill, thereby obtaining a cementitic structure. The process has both advantages and drawbacks. Steps must be taken not to harden the parts which must remain soft. The chills are, however, difficult to set and large numbers are lost.

(2) Cast the camshafts with an iron carrying low addition of special elements so as to obtain a soft iron in the as-cast state. The cranks are then qenched in oil after preheating by the acetylene flame, thereby obtaining a martensitic structure. The advantage of such a process is the elimination of chills. Nevertheless, this type of quenching is delicate and regularity of manufacture is difficult to control.

(3) Cast, using a chemical composition in the mix so that the crank is hardened through the use of damp sand, the rest of the casting remaining soft. This is the Ford process and very praiseworthy because it demands neither chills nor heat-treatment. It does, however, require the strictest supervision at the melting plant, so that the composition may be kept within well-defined and narrow limits.

In an earlier part of the article, Dr. Jungbluth compares the properties of cast iron and steel under alternating stress. The numerous graphite inclusions in cast iron, he points out, act as internal notches and render the material much less sensitive than steel with external notches in the case of alternating stress so that the fatigue limits of steel and iron become much closer than the tensile properties would lead one to expect. This is shown by Table I.

TABLE I.—*Fatigue Limit of Steel and Cast Iron According to Mailander.*

Material.	Breaking load.		Fatigue limit.			
			Without notch.		With notch.	
	Expressed in tons per sq. in.	Related to that of cast iron taken as unity.	Expressed as tons per sq. in.	Related to that of cast iron taken as unity.	Expressed as tons per sq. in.	Related to that of cast iron taken as unity.
Cast iron	18.4	1.00	8.2	1.00	8.2	1.00
Steel	24.1	1.32	13.3	1.62	8.89	1.08
Steel	37.5	2.04	18.4	2.23	11.4	1.39

Referring to the excellent wear-resisting properties of cast iron, the author points out that this is due to the presence of graphite, not directly so, but rather because the minute cavities it creates become filled with the lubricant. Moreover, the pearlitic structure which encloses the graphite is a high-grade wear-resisting material. Three types of alloys are well capable of being used as crankshafts: (1) High-duty pearlitic irons either with or without small special additions and with or without later heat-treatment; (2) martensitic irons, and (3) alloys of the type of malleable cast iron. The first type is characterised by (*a*) low carbon content when there are no special elements—it should be between 2.8 to 3.0 per cent. and there is no heat-treatment; (*b*) normal carbon content with nickel additions up to 2 per cent. and chromium up to 1 per cent. This iron can be used without heat-treatment; it can, however, be improved by oil-quenching from 800 to 900 deg. C., followed by tempering at 300 to 400 deg. C.

The martensitic iron, which falls into the second class, is hard in the as-cast state. It is necessary to carry out a softening treatment so that a Brinell hardness of 300 maximum may be reached to ensure ease in machining.

The third type is the most usually employed. Ford uses it on a wide scale. In the as-cast condition a white iron is produced. By using a double heat-treatment this iron is graphitised and is brought down to a Brinell hardness of 250 to 300, a state which ensures the best properties. Cupola electric-furnace duplexing is used for its production.

(*Continued at foot of previous column.*)

The Week's News in Brief

Trade Talk

HIDUMINIUM ENGINEERING, LIMITED, 115, Buckingham Avenue, Slough, Bucks, are now trading under the new name of High Duty Bronze, Limited, and under a new board of directors.

THE GLACIER METAL COMPANY, LIMITED, is beginning next month the payment of children's allowances to employees with three or more children under the age of 15 years. The payments will be 3s. a week for each child in excess of the first two.

GLOVER & WOOD, LIMITED, of 38-40, Victoria Road, Leeds, 11, have now completed the removal of their foundry department to premises at Low Moor, near Bradford, but all correspondence should be addressed to the Leeds office, to which is attached a reception and despatch department.

FOLLOWING NEGOTIATIONS between the National Union of General and Municipal Workers and the firm of Ideal Boilers & Radiators, Limited, Hull, a bonus of 5s. a week for all adult workers and 2s. 6d. per week for junior workers has been agreed upon. The payment of this bonus began as from February 24.

IN ORDER to co-ordinate war effort, the various organisations within the French foundry industry have formed a joint committee. The participating bodies are the Syndicat Général des Fondeurs de France (the employers' federation), the Association Technique de Fonderie, the Ecole Supérieure de Fonderie (the French Foundry School) and the Institut de Recherches de Fonderie.

AT A "Save Your Scrap" luncheon held by the Scottish Iron and Steel Scrap Association in Glasgow on February 21, the Lord Provost of Glasgow (Mr. P. J. Dollan) said that Glasgow Corporation departments collaborating in the campaign for waste-materials salvage had collected £10,000 since last September. In four months Glasgow householders had turned in approximately 800 tons of scrap.

A RESEARCH scholarship of the value of £250 per annum and tenable for two years has been founded by the Wrought Light Alloys Development Association to encourage and facilitate research in the application of light alloys to ship construction. The scholarship will be administered by a committee of the Institution of Naval Architects, and it is hoped to make the first award in September, 1940. Full particulars of entry, which closes on July 31, can be obtained from the Secretary, Institution of Naval Architects, 10, Upper Belgrave Street, London, S.W.1.

AT THE REQUEST of Sir Walter Monckton, Director-General of the Press and Censorship Bureau, Sir William Bragg, as President of the Royal Society, has undertaken the formation of a scientific panel to assist the bureau in arranging the censorship of Papers in scientific journals. The following have agreed to serve on the panel:—Prof. C. R. Harington (biochemistry), Prof. V. H. Blackman (botany and agriculture), Prof. A. C. Egerton (chemistry), Dr. H. L. Guy (engineering sciences), Prof. P. G. H. Boswell (geology), Prof. S. Chapman (mathematics), Dr. C. H. Desch (metallurgy), Dr. C. G. Darwin (physics), Prof. A. V. Hill (physiology), Prof. F. C. Bartlett (psychology), Prof. W. W. C. Topley (bacteriology and pathology), Prof. M. Greenwood (statistics), Sir Guy Marshall (zoology).

COMPLAINT is made by small engineering firms that the Government has placed certain companies "in such a position that they can afford to offer wages which are a temptation to even the most satisfied man to leave his ordinary employer." They state that they are being denuded of craftsmen who are attracted to other firms engaged on Government contracts by the high rates of pay offered. An approach has been made to the Ministry of Labour and National Service. It has been suggested that an order should be issued under the Control of Employment Act prohibiting advertisements for certain classes of labour in the engineering industry. Firms which have complained agree with the Ministry's view that no man should be prevented from exercising his right to offer his services wherever he desires. They hold, however, that the Government has placed certain firms in a position to offer extremely attractive rates.

Obituary

MR. D. W. RITCHIE, director of the Ritchie-Atlas Engineering Company, Limited, Glasgow, has died.

MR. W. D. BELL, J.P., managing director of Andrew Barclay, Sons & Company, Limited, Caledonia Engineering Works, Kilmarnock, has died.

THE DEATH occurred on February 23 of Mr. Robert Poole, chairman and managing director of Richmonds Gas Stove Company, Limited, of Warrington.

THE DEATH occurred on February 21 of Mr. J. B. Gilchrist, managing director of the Grange Foundry Company, Limited, Shettleston, Glasgow. He was 53 years old.

MR. THOMAS SPITTLE has died at Newport, aged 84. The foundry of which he was the head was one of Newport's earliest industries, and was founded by his grandfather.

THE DEATH recently occurred of Mr. David Ward, ironfounder and agricultural machinery merchant, of Long Melford, Suffolk. He sold his business in 1936, when he was 70 years old.

MR. CHARLES EDWARD GARDNER, a former Mayor and Sheriff of Gloucester, died at Gloucester on February 19. Aged 73 years, he was head of the firm of William Gardner & Sons (Gloucester), Limited, engineers.

MR. JOHN CRAIG, a director of G. & J. Weir, Limited, of Cathcart, has died. He was associated with the firm for about 60 years, being elected to the board before the last war. His special department was the supply of auxiliary machinery for shipping.

THE DEATH has taken place of Mr. C. M. Tate, of Burnley, who was engineer to the Towneley Coal & Fireclay Company, Limited, and who was well known to members of the Burnley Section of the Lancashire Branch of the Institute of British Foundrymen.

MR. JOSEPH PERCIVAL GILLOTT, a director of Marple & Gillott, Limited, iron and steel merchants, Sheffield, and of the Burton Constructional Engineering Company, Limited, Burton-on-Trent, died recently. Mr. Gillott, who was 58, had been in failing health for some months. He was widely known in the scrap metal industry.

WE REGRET to record the death on January 31 of Mr. J. H. Quicke, of the Madeira Engineering Company, Funchal, Madeira. Mr. Quicke had resided in Madeira for 15 years and was formerly manager of Leacocks Foundry. He was well known to many engineers and foundrymen in Great Britain and was a member of the London Branch of the Institute of British Foundrymen.

WE REGRET to record the death of Mr. Arthur Habershon, formerly connected with J. J. Habershon, of Holmes Mills, Rotherham. He was 80 years of age and was in business for many years as a stove-grate founder under the style of the Masbro Foundry Company, later to be taken over by the Holmes Steel & Foundry Company and finally by J. J. Habershon & Sons, Limited.

MR. HEDLEY STANLEY MOORWOOD, a director of Hedley Moorwood & Company, Limited, iron and steel merchants, died recently. He was formerly connected with the old-established business of Moorwoods, Limited, ironfounders, of Sheffield, which was founded in about 1846 by his father. His younger brother, Mr. John M. Moorwood, founded the firm of John M. Moorwood, Limited, roll manufacturers, Attercliffe, and is its principal director. Mr. Hedley S. Moorwood was 80 years of age.

COLONEL R. E. B. CROMPTON, who died on February 15 at the age of 94, was a distinguished engineer, with a long record of pioneer work in both mechanical road traction and electrical engineering. In the latter sphere he played a leading part in the commercial birth of electric lighting after developing steam traction in India. His interest in electricity began with the installation for the Stanton Ironworks of a dynamo and arc lamps in order to enable night shifts to be worked in a new foundry. About the same time he acquired an interest in the Bürgin dynamo, and began to make the machines in quantity at the works of Crompton & Company, which he founded at Chelmsford in 1878. He introduced improvements in the design of both dynamos and arc lamps, and of electrical measuring instruments. He was associated with Joseph Swan in exhibiting the latter's new carbon filament glow-lamps at Glasgow, with the practical result that he obtained orders to instal the lamps in the Glasgow Post Office and at Queen Street Station. He lighted his own house in London by electricity in 1881; his first large installation, running to 1,600 lamps, was at the Law Courts in 1883. Col. Crompton was also called in to assist in the design and construction of a central station in Vienna, which was the forerunner of a number of others with which he was concerned, on the Continent and in India. While the work at Vienna was in progress he attempted house-to-house lighting in London, and took the first stages leading to the formation of the Kensington Court Electric Lighting Company, afterwards the Kensington and Knightsbridge Electric Lighting Company, one of the first, if not the first, of the real public lighting undertakings. He was twice President of the Institution of Electrical Engineers, and served as President of the Institution of Automobile Engineers and of the Junior Institution of Engineers. He also organised and was President of the Commercial Motor Users' Association.

Personal

THE HON. R. H. VIVIAN SMITH has been elected a director of Vickers, Limited.

THE EARL OF DUDLEY is to join the board of the South Staffordshire Mond Gas Company.

SIR PATRICK HANNON, M.P., has been re-elected President of the Institute of Export for the second consecutive year.

MR. J. W. DOLPHIN has been appointed a director of Engineering Components, Limited, in place of Mr. J. E. V. Jobson.

MR. JOHN DIXON, of Dale Street, Lincoln, has been awarded the King's Medal for rescuing a crane driver from a perilous situation following upon fire which broke out in the foundry of Robey & Company, Limited, Globe Works, Lincoln.

MR. ASA BINNS, M.I.Mech.E., who until recently was chief engineer of the Port of London Authority, and who is now a consultant to the firm of consulting engineers, Rendel, Palmer & Tritton, has been elected President of the Institution of Mechanical Engineers for the year 1940.

MR. T. H. THATCHER, of the Atlas Preservative Company, Limited, Erith, who had acted as honorary treasurer of the Institute of Export since its inception in 1935, has relinquished that office. A presentation in recognition of his services was made to him following the annual meeting in London last week.

MR. H. E. YEATES, managing director of Ideal Boilers & Radiators, Limited, of Hull, has resigned from that position, which he has occupied for about forty years, if the firm's predecessors, the National Radiator Company, be included. He is to remain on the directorate, and Mr. G. E. Downe, previously works manager, is now managing director.

Wills

BAIRD, WILLIAM, engineer and bridge builder, Temple Ironworks, Anniesland, Glasgow £11,079

MCKENNA, THOMAS, of Saltburn-by-the-Sea, general secretary of the National Union of Blast-furnacemen ... £1,328

Forthcoming Events

MARCH 6.

Manchester Metallurgical Society:—"Use of the Microscope," Paper by H. Wrighton, at the Engineers' Club, Manchester, at 6.30 p.m.

MARCH 8.

Manchester Association of Engineers:—Annual dinner and dance, at Grand Hotel, Piccadilly, Manchester, at 7 p.m.

Institute of British Foundrymen

MARCH 2.

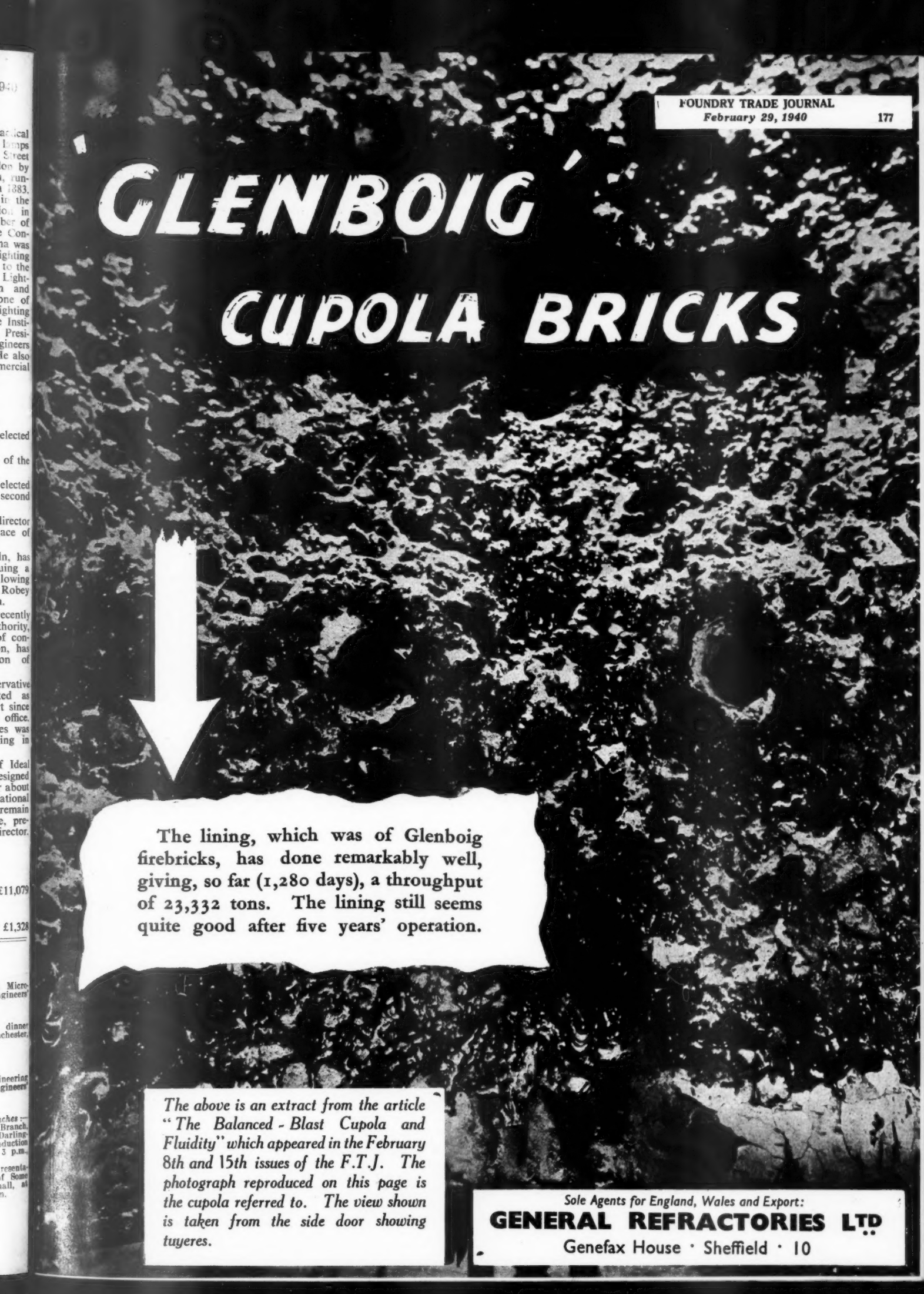
Lancashire Branch:—"Production of Some Engineering Castings," Paper by A. Marshall, at the Engineers' Club, Manchester, at 3 p.m.

MARCH 9.

Middlesbrough and Newcastle-upon-Tyne Branches:—Joint meeting arranged by Middlesbrough Branch, at Temperance Institute, Gladstone Street, Darlington. "Development of Steel Foundry Production Methods," Paper by Dr. C. J. Dadswell, at 3 p.m., followed by tea in Queen's Hall, at 5 p.m.

Scottish Branch:—Annual general meeting. Presentation of John Surtees Medals. "Production of Some Engineering Castings," Paper by A. Marshall, at Royal Technical College, Glasgow, at 3.30 p.m.

'GLENBOIG' CUPOLA BRICKS



The lining, which was of Glenboig firebricks, has done remarkably well, giving, so far (1,280 days), a throughput of 23,332 tons. The lining still seems quite good after five years' operation.

The above is an extract from the article "The Balanced - Blast Cupola and Fluidity" which appeared in the February 8th and 15th issues of the F.T.J. The photograph reproduced on this page is the cupola referred to. The view shown is taken from the side door showing tuyeres.

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Raw Material Markets

National defence requirements continue to require the unremitting efforts of iron and steel producers, and there is still only a limited surplus of certain descriptions available for distribution to other consumers at home and abroad. As far as the export market is concerned, it is hoped that there will be an expansion of shipments later in the year; a substantial business is offering. The spring is expected to provide opportunities for the importation of larger tonnages of scrap, ore and steel semis.

Pig-Iron

MIDDLESBROUGH—Heavy deliveries of Midlands iron to foundries in the Cleveland area continue to arrive, but while this is satisfactory to a certain extent, transport facilities are not always freely available, as was witnessed earlier in the year. Ironmakers in this district are fully employed on the production of material for the steelworks. It is undesirable to tax the railways when it might be possible to obtain iron from local works, and a resumption of production on foundry grades may be found practicable at a later date. Hematite and special descriptions of iron are well taken up by the steelworks, where consumption is at a high level. In addition to the local demand, there is pressure for supplies from users in other districts, including the Midlands and Sheffield. Business is largely on a hand-to-mouth basis, forward contracting being discouraged, as the current demand is about equal to the available supply. Little can be done in the export trade on account of the strength of home needs, but there is a large number of inquiries which could be turned into firm business at any time should there be hematite to spare for shipment.

LANCASHIRE—Foundry iron users in this area continue to receive quite heavy deliveries, although business is still on a week-to-week basis. Many users would doubtless like to accumulate stocks, but this is not at present possible; however, the Control is succeeding in providing all consumers with sufficient to meet their immediate requirements. Heavy electrical engineers and the machine-tool trade, together with other specialised concerns, are well employed, but many jobbing foundries and light-castings makers are still badly placed for orders. A steady movement in West Coast hematite is reported.

MIDLANDS—Business in foundry iron is brisk, and the requirements of local users are being quite well met, although only early needs can be satisfied. High-phosphorus iron is obtainable with little delay, as this grade is largely used by light-castings makers, most of whom are still working only intermittently. There is little Government work available for this trade as yet, and, until the services of this branch are required in the national effort, there is unlikely to be much improvement, as the building industry, the largest peacetime support of the light-castings industry, continues to operate at a low level. In addition, the falling off in the overseas market has adversely affected the light foundries. Low-phosphorus iron and hematite are both well taken up by the heavy engineering concerns and other establishments engaged on work of national importance. If anything, the past few weeks have witnessed an expansion in the demand for these grades.

SCOTLAND—There are few complaints as to supplies of pig-iron in this area. Although it is not possible to allow users to build up reserves, there is a steady flow of deliveries to the consuming works, which facilitates continuous operations. The full output of the furnaces is being taken up, and stocks are consequently low at the producing end. Trade in the Falkirk district, where most of the light-castings makers have their factories, is not at all good, but there has certainly been an improvement since the outbreak of war, although the amount of Government work placed here is still of very small proportions. Makers are relying on procuring national defence work in the future: if they are not so favoured there is little likelihood of these concerns seeing better days until after the war, as the prospects in the building trade are not bright.

Coke

Although the severe weather experienced a few weeks ago had the effect of slowing down deliveries of coke very considerably, the majority of consumers were not seriously inconvenienced, as many of them had taken the precaution of stocking supplies. Current specifications are quite brisk, and the coke ovens are busily engaged. For delivery to Birmingham and Black Country stations, the price of Durham best foundry coke is 53s. per ton. This price is controlled and is subject to change at any time. Producers are willing to enter into forward business up to the end of June, but all contracts carry a stipulation with regard to price changes.

Steel

Steelworks generally are fully booked over as long a period as they care to go in the circumstances, and new orders are accepted without any time being specified for delivery. If no fresh orders were forthcoming the industry would be fully employed for months ahead in disposing of existing commitments. The needs of overseas consumers are only being met in small part, but by careful control of the industry it is hoped to make larger supplies available later in the year.

Scrap

With unprecedented demands still being made on the resources of the scrap iron and steel trade, the efforts to make available as much home-produced material as possible are going ahead with gratifying results. Particular attention is being paid to the agricultural districts, where substantial tonnages of scrap are to be found lying idle on the farms. Foundries are still showing a keen interest in heavy foundry cast-iron scrap, and all available supplies are being pressed into immediate use. Imports continue to arrive, but it is hoped to accelerate the movement in the spring.

Metals

At the meeting of the International Tin Committee on Monday the quota for the second quarter of the year was reduced to 80 per cent. of standard tonnages, a cut of 40 per cent. compared with the current level of production. An output of 80 per cent. represents approximately 181,000 tons per annum, or about equal to current consumption at present price levels. There had been a considerable amount of conjecture regarding the Committee's ultimate decision, but the result has not altogether surprised tin circles. In some quarters it is felt that an 80 per cent. quota leaves insufficient margin over consumption, but, on the other hand, stocks have increased appreciably in recent months. As far as supplies for the United Kingdom are concerned, obviously the greatest care must be shown during the war and stocks must be maintained at a higher level than is customary on account of the possibility of shipping becoming irregular. However, with stocks at a high level, the position can be regarded as satisfactory, as the output restrictions are flexible and may be adjusted at any time to meet unforeseen requirements.

Substantial shipments of American tin to Russia, the ultimate destination of the metal believed to be Germany in many instances, have resulted in the New York Commodity Exchange forbidding its members to buy tin for re-export, according to advices received in London on Tuesday. Some 3,000 tons of tin are believed to have been re-exported from America since the outbreak of war.

The February issue of the Statistical Bulletin of the International Tin Research and Development Council, which may be obtained from the Statistical Office, 21, Prinsessegracht, The Hague, price 1s., states that it could be expected that after the exceptionally high figure of world tin production in December, the figure for January would show a reaction. The January figure is estimated at 17,000 tons, or about 10,000 tons lower than that for December. Production in the first five months of the war amounted to 113,400 tons or an average of 22,700 tons a month. World apparent tin consumption in the first month of the year is estimated at 22,600 tons, but this figure must be regarded as a provisional one, as, apart from the figures for the deliveries of the principal smelters, very few figures were available when the estimate was made. World apparent consumption in the past five months amounted to 86,200 tons, or 17,200 tons a month, on an average, whereas the use of tin in manufacture is estimated at about 15,000 tons. These figures indicate that in the past five months a quantity of about 11,000 tons has served to enlarge consumers' stocks. Visible stocks, too, have increased in the past five months, and the increase in stocks amounted to more than 25,000 tons. This increase in the world stocks of tin has been necessary because, owing to the war conditions now prevailing, there are many factors disturbing the regular supply.

Metal market prices for tin were as follow:—*Cash*—Thursday, £244 15s. to £245; Friday, £245 10s. to £246; Monday, £247 to £247 5s.; Tuesday, £254 10s. to £254 15s.; Wednesday, £252 to £252 5s.

Three Months—Thursday, £244 15s. to £245; Friday, £244 10s. to £245; Monday, £246 10s. to £246 15s.; Tuesday, £254 10s. to £254 15s.; Wednesday, £252 to £252 5s.

Copper consumers in the United Kingdom continue to work at a high rate of capacity and applications for licences for fresh supplies are plentiful. The Control issues licences quite freely so long as the user requires the metal for work of national importance and deliveries to these concerns are satisfactory on the whole, but some other users are experiencing difficulty at times in procuring adequate tonnages. In the United States, most consumers are fairly well covered for their early requirements and are not expected to enter the market for a month or two to come. In December last United States exports of refined copper totalled 56,012 short tons, against 33,739 tons in the previous month, making a total for the year of 372,665 tons. Imports of refined metal in December were also heavier, being 42,816 tons of copper content, against 18,667 tons in November, and a total for the twelve months of 245,129 tons, as compared with 176,796 tons in the previous year.

A recent New York report stated that a Soviet freighter was loading 12,000 tons of copper and lead at the Mexican port of Manzanillo, for shipment to Vladivostock. It is presumed that the ultimate destination of the metal will be Germany. It is reported from the United States that a large part of the exports from America to the Soviet Union in January, valued at £2,828,250, were of copper and metal-working machinery.

The brass industry continues to be in the market for large tonnages of spelter, while the galvanisers, too, are as busy as the steel supply will allow. The latter are able to pay some attention to the export trade. Consumers of lead involved in Government work are receiving satisfactory deliveries, but there is little to spare for many other users who would like to obtain increased tonnages. In the United States there has recently been more business moving in lead.

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